

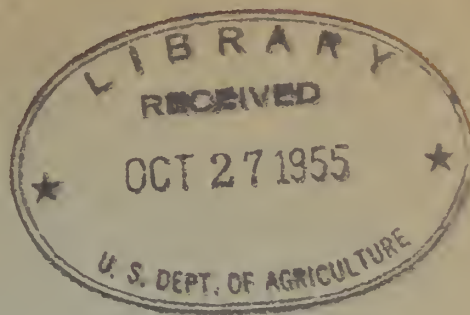
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UNITED STATES DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE  
WASHINGTON, D. C.  
H. H. BENNETT, CHIEF



ADVANCE REPORT  
on the  
SEDIMENTATION INVESTIGATIONS  
of  
RESERVOIRS AND NAVIGATION IMPROVEMENTS  
on the  
NEW RIVER, VIRGINIA AND WEST VIRGINIA

April 14 - May 22, 1936

by

Carl B. Brown and Farrell F. Barnes

Water Utilization Section

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Division of Research  
Section of Hydrodynamic Studies  
SCS-SS-6  
August, 1936



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## INTRODUCTION

This report presents the results of field investigations by the Soil Conservation Service, United States Department of Agriculture, during April and May, 1936, relating to the effects of accelerated soil erosion on reservoirs and navigation improvements on the New River between its headwaters and Hinton, W. Va. These investigations include (1) surveys of storage depletion and sedimentation in four reservoirs, (2) measurements on three former navigation channels, and (3) geological examination of silting conditions.

The New River rises in the Blue Ridge of northwestern North Carolina near the Tennessee State line. It flows northeast to the vicinity of Radford, Va., where it turns abruptly northwest and crosses the boundary into West Virginia, keeping the same general trend through that State to Gauley Bridge where it joins the Gauley River to form the Kanawha River. The Kanawha River continues northwest, past Charleston to Point Pleasant, W. Va., where it empties into the Ohio River.

The four reservoirs surveyed are:

- (1) Washington Mills Reservoir at Fries, Va.
- (2) Byllesby Reservoir, 6 miles southeast of Ivanhoe, Va.
- (3) Buck Reservoir, 3 miles southeast of Ivanhoe, Va.
- (4) Fields Manufacturing Company Reservoir, 4 miles north-east of Mouth of Wilson, Va.

The three navigation improvements investigated are located respectively:

- (1) about 8 miles above Hinton, W. Va., and 1.1 miles above Haines Ferry; (2) about 18 miles above Hinton, W. Va., at the mouth of Indian Creek; (3) about 20 miles above Hinton, W. Va., and about 1.75 miles above the mouth of Indian Creek.

The locations of the reservoirs and navigation improvements are shown in Figure 1.

## OBJECTIVES AND SCOPE

It has been known for many years that deforestation and cultivation of steeply sloping lands in the headwater areas of the mountain provinces of North Carolina, Virginia, and West Virginia were resulting in rapid and excessive erosion of topsoil and subsoil layers. In many sections large expanses of rock have been laid bare by complete removal of all soil covering, while additional areas have been disfigured and rendered wholly unfit for further agriculture by severe gullying.

Although repeated observations have been printed on the causes and consequences of soil erosion as applied to agricultural lands in this region, little or no attempt has been made either to measure quantitatively the rate of removal, or to account for the transportation and deposition of erosional debris. This lack of quantitative data and its

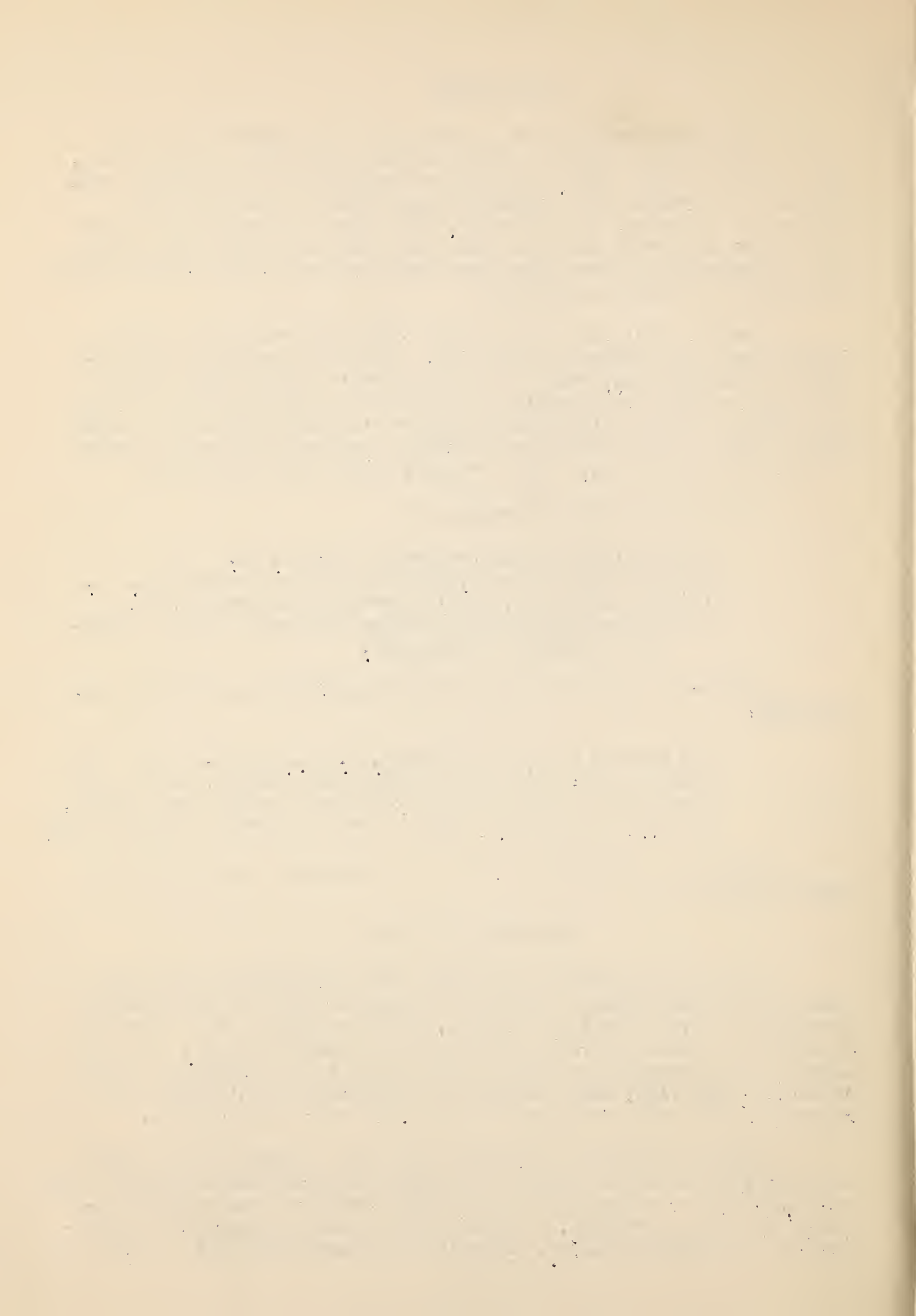
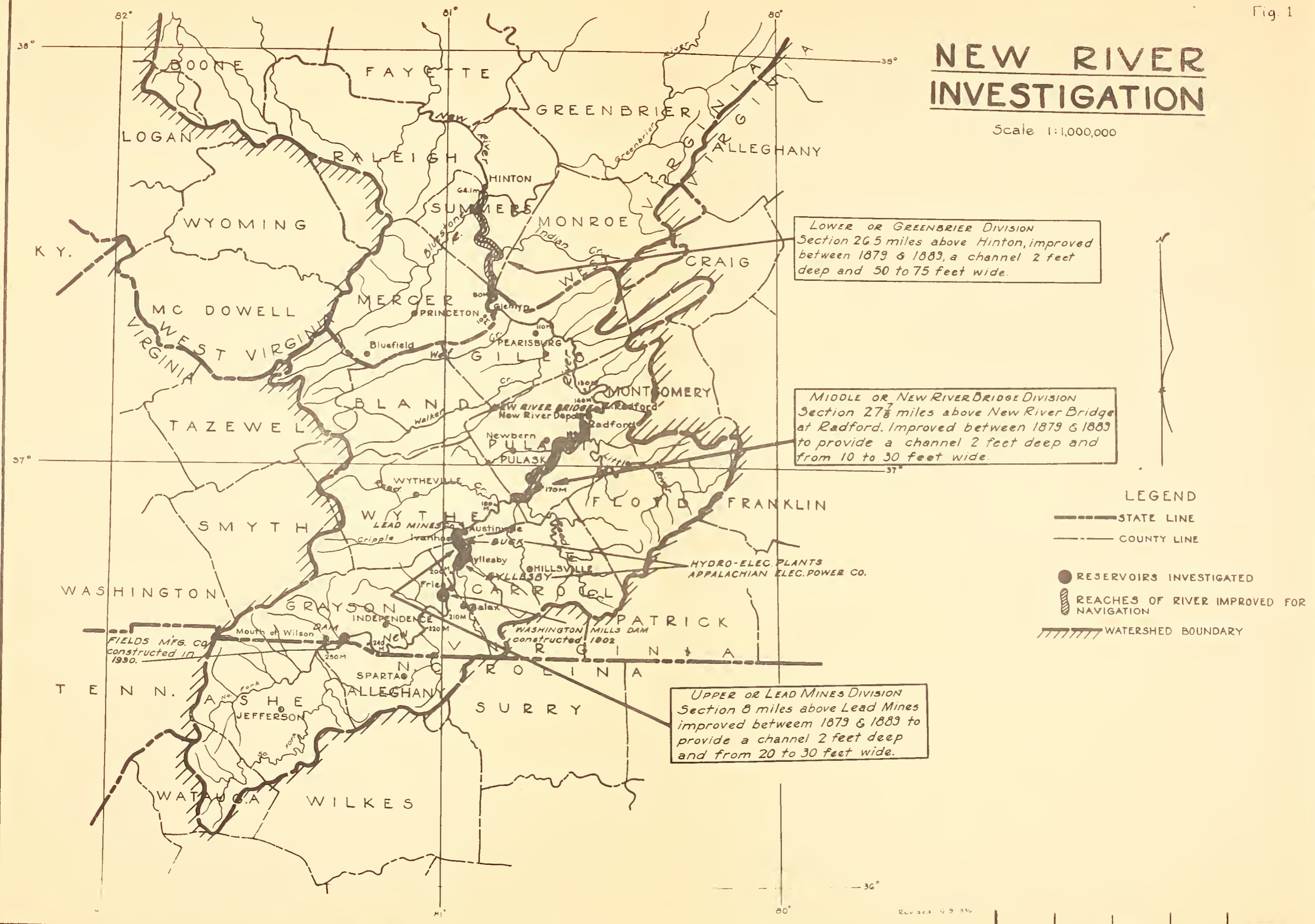


Fig. 1

# NEW RIVER INVESTIGATION

Scale 1:1,000,000



LOWER OR GREENBRIER DIVISION  
Section 26.5 miles above Hinton, improved  
between 1879 & 1889, a channel 2 feet  
deep and 50 to 75 feet wide.

MIDDLE OR NEW RIVER BRIDGE DIVISION  
Section 27 $\frac{7}{8}$  miles above New River Bridge  
at Radford. Improved between 1879 & 1889  
to provide a channel 2 feet deep and  
from 10 to 30 feet wide.

UPPER OR LEAD MINES DIVISION  
Section 8 miles above Lead Mines  
improved between 1879 & 1889 to  
provide a channel 2 feet deep  
and from 20 to 30 feet wide.

- LEGEND
- STATE LINE
  - COUNTY LINE
  - RESERVOIRS INVESTIGATED
  - REACHES OF RIVER IMPROVED FOR NAVIGATION
  - WATERSHED BOUNDARY



need in planning future control measures led the Soil Conservation Service to undertake the investigations described in the following pages during April and May, 1936.

The studies consisted of quantitative surveys by the Section of Hydrodynamic Studies, Division of Research, to determine the effects of erosional debris on reservoir storage and navigation improvement of the New River.

The principal developments consist of four major dams, one of which was constructed in 1902, two in 1912, and one in 1930. There are also numerous smaller dams and mill ponds, and navigation channels constructed during the period 1878-89. The measurement of the rate of sedimentation or silting of reservoirs has been used by the Soil Conservation Service for 2 years in the determination of debris output of various watersheds. The field staff assigned to these investigations was, therefore, thoroughly experienced by previous similar studies to undertake this work. The surveys were based on rigorous standards, tested and proved by more than thirty previous surveys. In such investigations the surveys of small, manipulative reservoirs have yielded the highest order of accuracy that has yet been obtained.

The direct objective of each survey was to determine both the original capacity and the present capacity of each reservoir and to study silt deposits, thereby determining the character, volume, and distribution of the sediment derived from erosion in the drainage area.

Studies of navigation improvements were made with two objectives in mind; (1) To determine the character of bottom and configuration of representative channels for comparison with old descriptions, and (2) to determine the approximate velocity of current through these channels as an indication of the size of material which could be transported.

Hence, in brief summary, the broad objectives of these investigations were:

- (1) To determine the minimum net erosion of the upper New River drainage area as measured by deposition in the reservoirs.
- (2) To ascertain the average rate of storage depletion from silting of existing reservoirs in the upper New River drainage basin.
- (3) To establish a basis for prediction of average annual losses of storage by silting in future reservoirs which may be constructed on the river - and thereby to measure the effectiveness and permanence of such developments in a coordinated program of soil conservation, flood control, navigation, and power improvement.
- (4) To determine what effects, if any, erosion, silting, and floods may have had on navigation improvements constructed on the river at government expense during the period 1878-89.



## METHODS OF INVESTIGATION

Reservoir Surveys.- Two general methods of procedure were followed in making the reservoir sedimentation surveys, namely, the range method, and the contour method. The range method consists of (1) mapping the present and original shore lines by plane table triangulation and stadia control to determine surface areas, (2) water depth measurements by soundings along parallel cross ranges, and (3) the determination of sediment thicknesses along the same ranges by means of a silt-sampling spud and boring apparatus. Original and present capacities are computed by a special formula <sup>1</sup> from surface areas and areas of plotted cross sections showing the original and present reservoir bottoms along each range.

The contour method involves the comparative measurement of storage volumes from a contour map of the original reservoir basin and a map made on the same scale and contour interval using the same elevation datum, prepared at the time of present survey. In some cases, as in Washington Mills Reservoir, it is necessary to reconstruct the original basin contour map by borings and other means described below. Volumes contained between each two successive contour elevations are computed by a modified prismoidal formula, the sum of all such volumes being the total capacity of the lake. The difference in the volumes contained between any two original contours and the corresponding present contours represents fill, and the sum of the differences for each contour interval is the total volume of sediment in the reservoir.

Excessive thicknesses of sediment require the use of the contour method when a reliable original contour map is available. When penetration to original bottom by spudding apparatus is possible, the range method of volume determination is preferable. The methods used in the survey of each of the four reservoirs covered in this investigation were determined by local conditions and the availability of reliable contour maps of the original reservoir basins.

Washington Mills Reservoir. - A map of Washington Mills Reservoir showing the original basin conditions was not available when this survey was undertaken. Although the range method of survey does not require an original map, the impossibility of penetrating the excessive thicknesses of sediment in Washington Mills Reservoir with the regular silt-sampling apparatus precluded its use in this survey. An examination of the basin and of river reaches above and below the reservoir suggested methods by which the original basin could be reconstructed with a reasonable degree of accuracy in the time available for the survey.

The valley of the New River for many miles both above and below the reservoir has, in general, the form of a simple trough with steep but uniformly sloping walls, a remarkably flat bottom, and a consistently

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<sup>1</sup> Eakin, H. M., Instructions for Reservoir Sedimentation Surveys: U.S.D.A., SCS-SS-2, p. 13, 1936.

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steep gradient. It was therefore possible, by measuring and plotting slopes at frequent intervals along the shore lines, by prorating the total fall between the dam and backwater shoals along the center line of the reservoir channel, and by taking scattered borings to the original bottom on exposed bars and islands within the basin, to obtain adequate control for reconstructing the original basin contours at 5-foot intervals. The only likely source of error in this method would be the presence in the basin of unusual topographic features, such as islands or deep pools, but interviews with several local residents who were familiar with the river before the dam was built failed to disclose a knowledge of any such features.

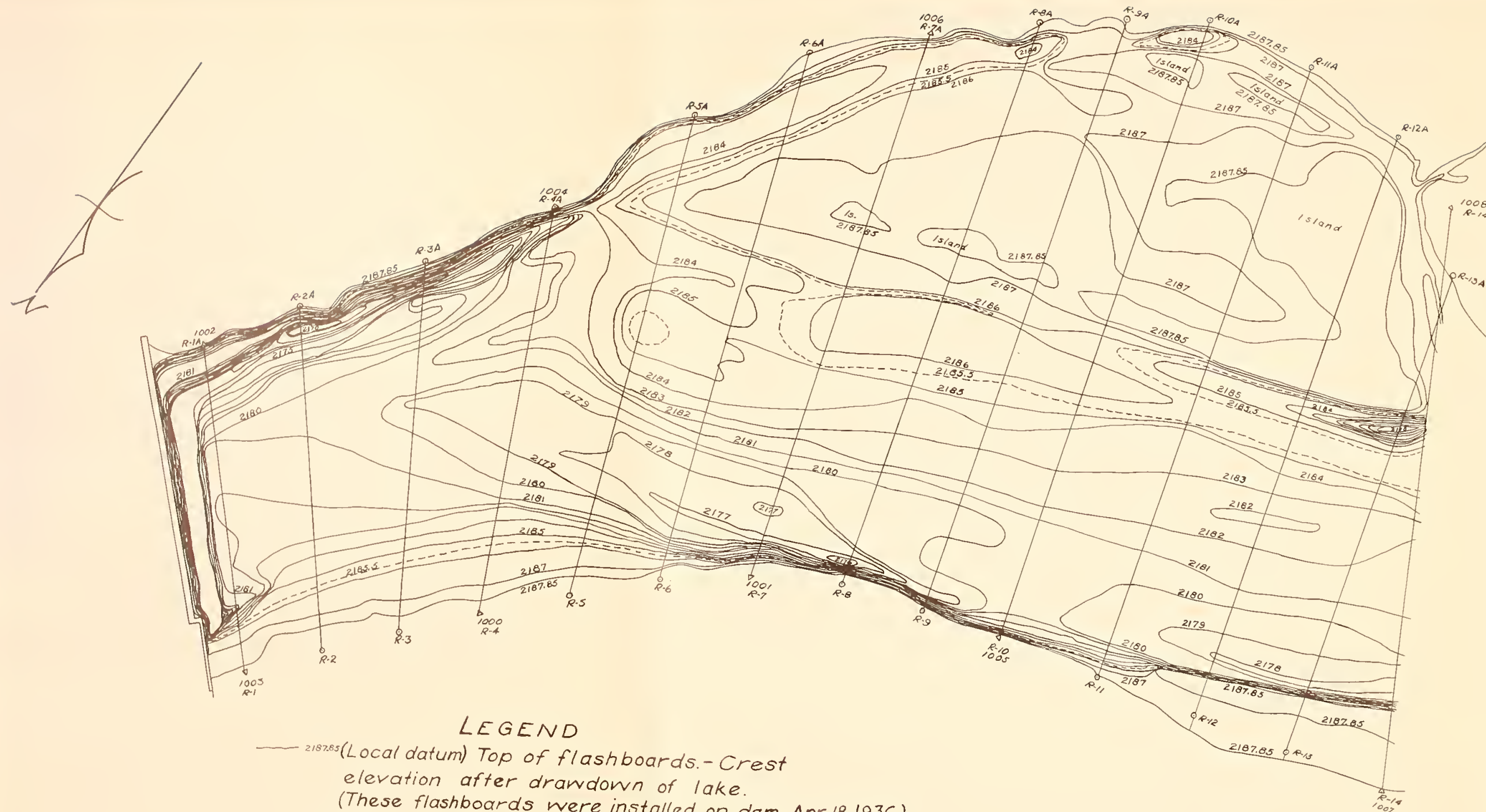
The present configuration of the basin was obtained by mapping the existing shore line and taking soundings along closely spaced ranges. Original and present capacities and silt volumes were computed from the areas enclosed by each set of contours.

It was possible, in the case of Washington Mills Reservoir, to make a comparison of the rate of sedimentation in those parts of the lake's history preceding and following the year 1922. In that year, an investigation was made to determine the feasibility of restoring storage capacity by dredging, and a map of the reservoir was prepared showing depths below crest level at closely spaced intervals. From this information a contour map representing the bottom of the reservoir at that time was prepared during the present survey, and compared with similar maps showing original and present contours. In this way, the volumes of sediment deposited in the periods 1902-22 and 1922-36 were determined.

A special study of the effects of a single complete draw-down of the reservoir was also made. Soundings were taken in the lower 2,400 feet of the reservoir on April 17, 1936. On April 18, the five headgates, with bottoms 20 and 22 feet above the original stream bed at the dam, were opened from 7:00 a.m. to 4:00 p.m., allowing all the stored water and the normal discharge of the river to flow out. To determine the volume of sediment flushed out by this process, the part of the lake affected by the scouring, that is, the lower 2,400 feet, was resounded on April 23. Two contour maps were made from the two sets of soundings, taken before and after draw-down, and from these the volume of sediment evacuated from the reservoir was determined. ( figs. 2 and 3).

Byllesby Reservoir. - Byllesby Reservoir was surveyed by the contour method of volume determination, since the thickness of silt in most of the reservoir was too great for direct measurement with spudding apparatus. This type of survey was made possible by the availability of a blueprint of an original map of the reservoir with a scale of 1 inch to 200 feet, and a contour interval of 10 feet. Due to certain omissions on this original map, the original bottom profile of the river was checked by a series of 15 auger borings through the silt deposits taken along the main channel and the Crooked Creek arm. The present crest level shore line and dam were mapped by stadia from triangulation control, and the basin below crest level was mapped by soundings along parallel ranges (fig. 4).





WASHINGTON MILLS RESERVOIR  
NEW RIVER  
FRIES, VIRGINIA  
STUDY OF EFFECTS OF DRAWDOWN

IN 2 SHEETS

SHEET NO. 1

SCALE 1" = 200 FEET

SOUNDINGS - APRIL 17, 1936

BEFORE DRAWDOWN

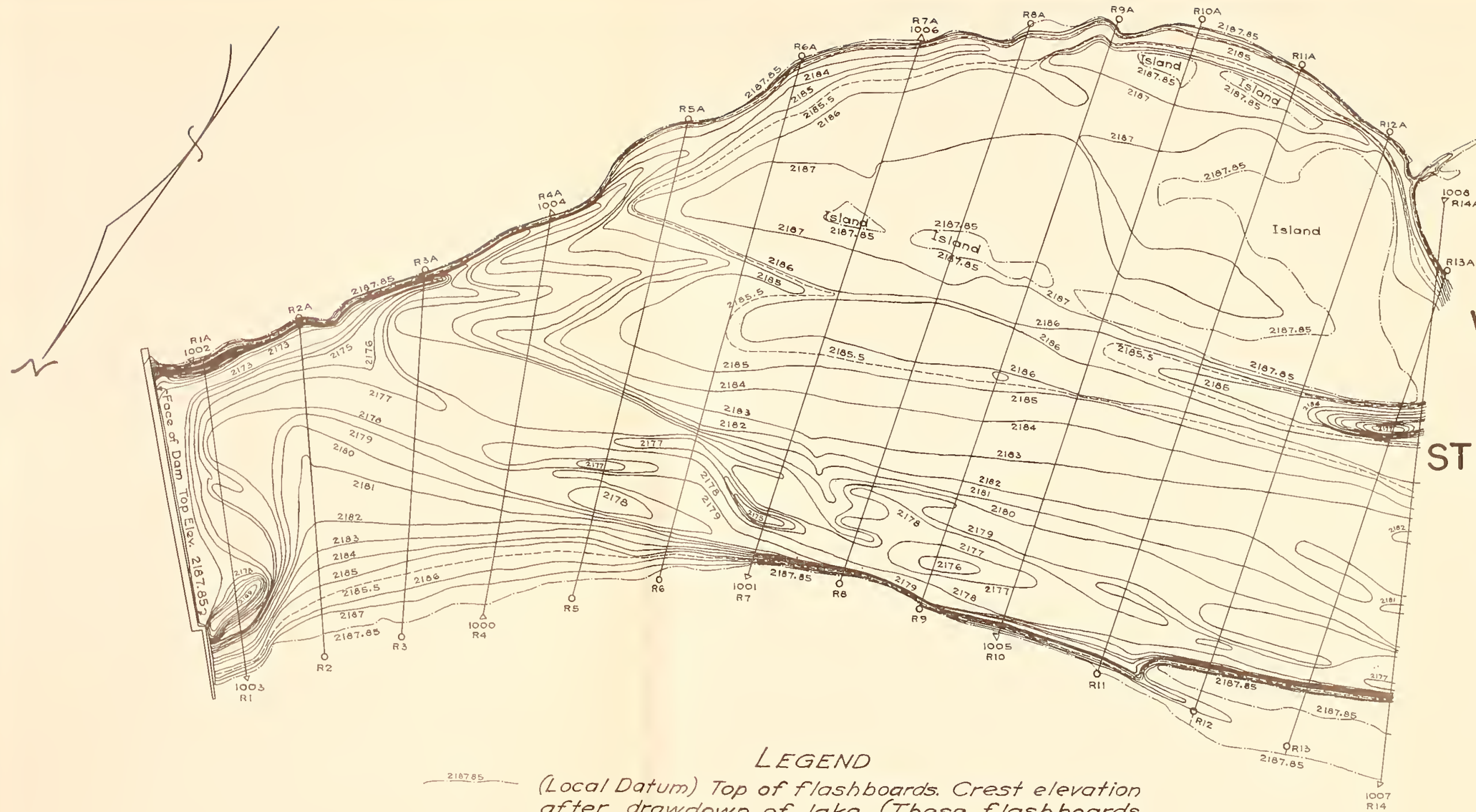
DIVISION OF RESEARCH

SEDIMENTATION &amp; HYDRAULIC STUDIES

## LEGEND

- 2187.65 (Local datum) Top of flashboards. - Crest elevation after drawdown of lake.  
(These flashboards were installed on dam Apr. 18, 1936.)
- - - 2185.5 Top of concrete spillway. - Crest elevation before drawdown of lake.
- △ 1003 Triangulation station.
- R-1 — R-1A Range





WASHINGTON MILLS RESERVOIR  
NEW RIVER  
FRIES, VIRGINIA  
STUDY OF EFFECTS OF DRAWDOWN

IN 2 SHEETS

SHEET NO. 2

SCALE - 1" = 200'

SOUNDINGS APRIL 23, 1936 — AFTER DRAWDOWN

DIVISION OF RESEARCH

SEDIMENTATION &amp; HYDRAULIC STUDIES

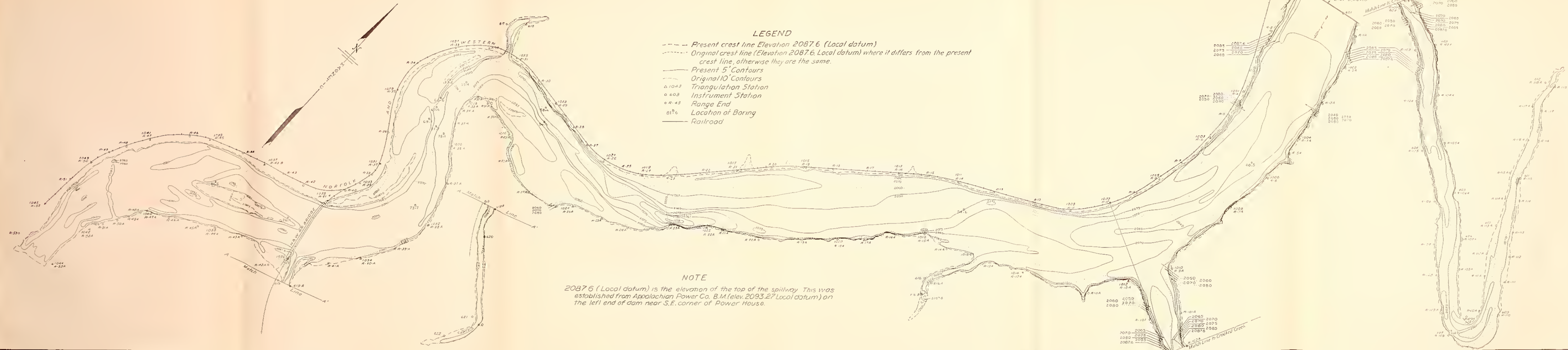
## LEGEND

- 2187.85 — (Local Datum) Top of flashboards. Crest elevation after drawdown of lake. (These flashboards were installed on dam April 18, 1936.)
- - - 2185.5 - - - (Local Datum) Top of concrete spillway. Crest elevation before drawdown of lake.
- △ 1003 Triangulation station.
- R1 — R1A Range.



BYLLESBY RESERVOIR  
NEW RIVER  
BYLLESBY, VIRGINIA  
SEDIMENTATION SURVEY

SCALE: 1" = 400'  
DATE OF SURVEY = APR.23 TO MAY 19, 1936  
DIVISION OF RESEARCH  
SEDIMENTATION & HYDRAULIC STUDIES



### LEGEND

- Present crest line Elevation 2087.6 (Local datum)
- Original crest line (Elevation 2087.6, Local datum) where it differs from the present crest line, otherwise they are the same.
- Present 5' Contours
- Original 10' Contours
- Δ 1043 Triangulation Station
- o 603 Instrument Station
- o R-43 Range End
- BL 66 Location of Boring
- Railroad

NOTE

20876 (Local datum) is the elevation of the top of the spillway. This was established from Appalachian Power Co. B.M.(elev. 2093.27 Local datum) on the left end of dam near S.E. corner of Power House.



Buck Reservoir. - Buck Reservoir was surveyed entirely by the range method. Although the original bottom could not be reached in all parts of the reservoir by spudding, penetration of the thicker and more compact deposits was easily obtained by boring apparatus, consisting of a spiral auger at the end of several feet of pipe, operated from a boat held stationary by anchors. The shore line was mapped by stadia from triangulation control and the present and original profiles were determined along nine parallel cross ranges ( fig. 5).

Fields Manufacturing Company Reservoir. - The reservoir of the Fields Manufacturing Company was also surveyed by the range method. The procedure was the same as for Buck Reservoir, except that small thicknesses of sediment permitted use of the spudding apparatus throughout (fig. 6).

### NAVIGATION CHANNELS

Three navigation channels, 8, 18, and 20 miles, respectively above Hinton, W. Va., were chosen for detailed measurements. At each location the average slope of the channel was determined by levels, one or more typical cross sections were located and measured by stadia and plane table, and current velocities were measured by means of surface floats. From these data the mean velocity and discharge were computed. The bottom of each channel was explored to determine the presence or absence of sediment.

### HISTORY OF INVESTIGATION

Detailed sedimentation surveys of four reservoirs and velocity and discharge measurements of three navigation channels on the New River were made during the period April 14 to May 22, 1936, by the Eastern Field Party, Section of Hydrodynamic Studies, Division of Research, of the Soil Conservation Service. The personnel consisted of seven engineers, three geologists, and one forester, under the direction of Louis M. Seavy, Chief of Party.

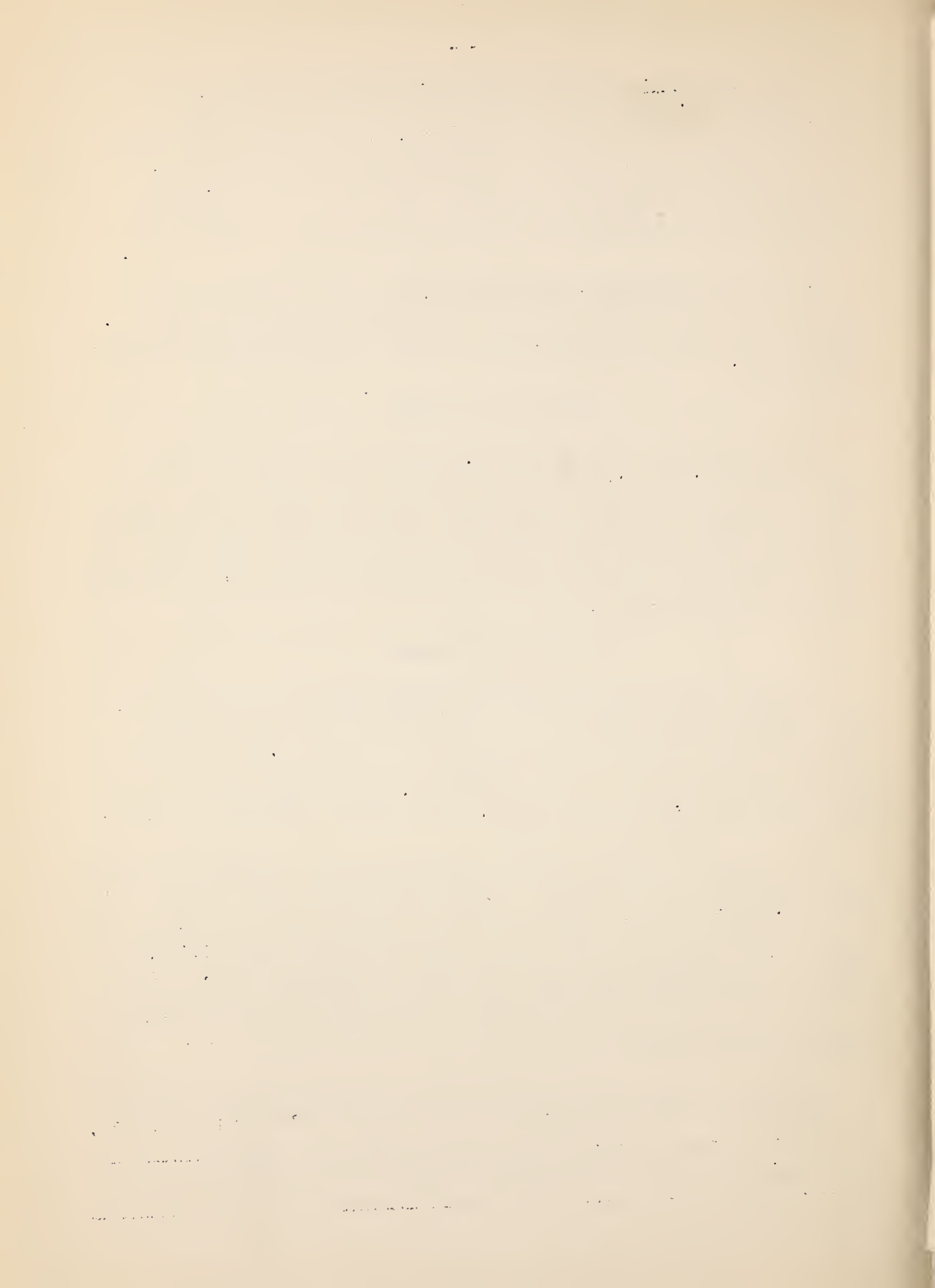
The survey of Washington Mills Reservoir was made during the period April 14 to May 2 and involved contour mapping on a 1-foot interval. <sup>2/</sup> of 150.5 acres of silt deposits, and the remapping after a desilting operation of a 46.4-acre area immediately above the dam. In addition, the river channel was mapped on a 1-foot contour interval for 1,100 feet below the dam and 1,400 feet above the head of backwater. Slope readings of the valley sides along both shore lines, and 18 borings to original bottom through bars and islands were made in order to reconstruct the original basin contours.

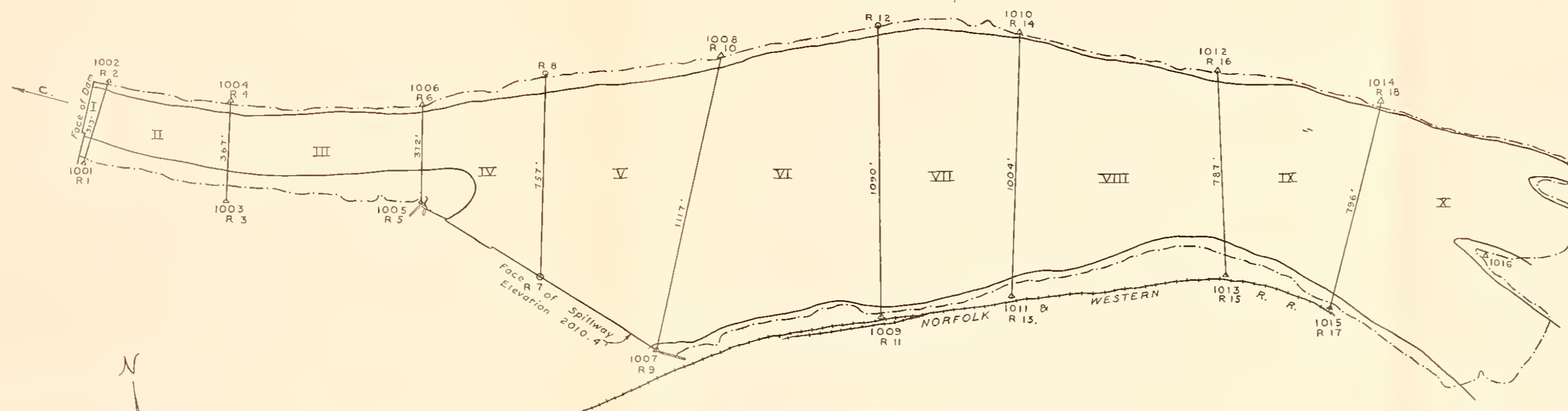
Byllesby Reservoir, with a total area of 340.5 acres was surveyed by the contour method on a 5-foot interval between April 23 and May 19.

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<sup>2/</sup> Five-foot contours only are shown on the final map, fig. 8.

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## LEGEND

2010.4 (Local Datum) Crest Elevation  
 Banks of old stream channel  
 Triangulation station  
 Silt range

## NOTE

2010.4 (local datum) is the average elevation of the top of the spillway, established by the Appalachian Electric Power Co. from their B.M. (elevation 2014.98 - local datum) on the right wingwall of the spillway.

For Mean Sea Level datum add 8.017 to local datum.

BUCK RESERVOIR  
 NEW RIVER  
 IVANHOE, VIRGINIA  
 SEDIMENTATION SURVEY

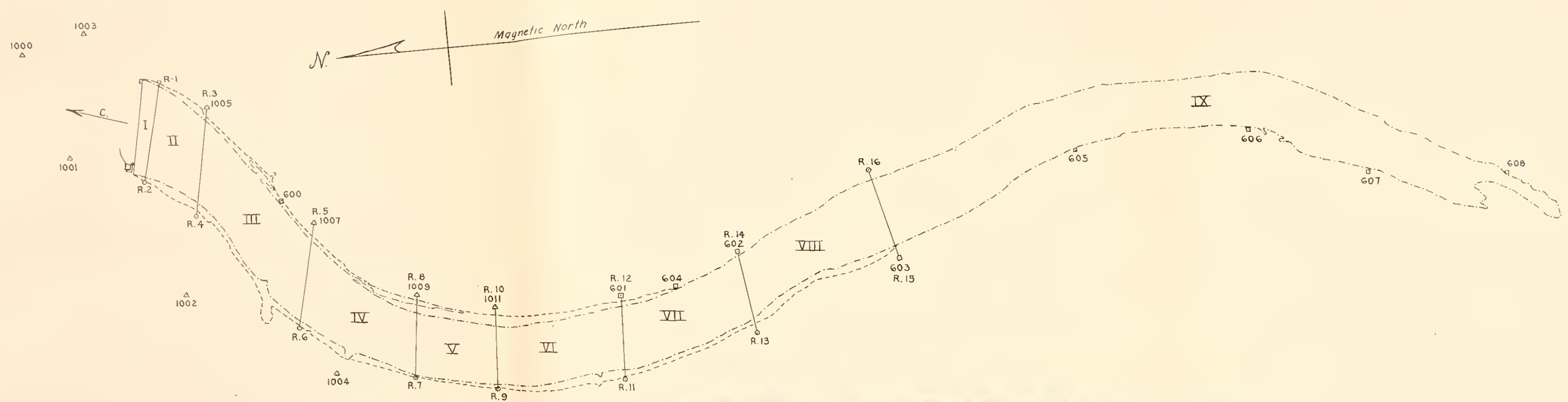
SCALE 1" = 400'

DATE OF SURVEY: MAY 11 TO 15, 1936

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# FIELD'S MANUFACTURING CO. LAKE

NEW RIVER

INDEPENDENCE, VIRGINIA

## SEDIMENTATION SURVEY

SCALE 1" = 400'

DATE OF SURVEY: MAY 16 TO 21, 1936

DIVISION OF RESEARCH

SEDIMENTATION & HYDRAULIC STUDIES

### LEGEND

- Present Crest Line elevation 100' (Assumed datum)
- \_\_\_\_\_ Original Crest Line elevation 100' (Assumed datum)
- △ 1001 Triangulation Station.
- R.1 150' R.2 Silt Range.
- 605 Instrument Station.

### NOTE

100' is the assumed elevation of the top of the spillway



Buck Reservoir was surveyed by the range method during the period May 11 to May 16. The work included the mapping of 92.8 acres and the sounding and boring of 9 ranges.

Field Manufacturing Company Reservoir was surveyed by the range method during the period May 16 to May 21. An area of 46.1 acres was mapped and 8 ranges were sounded and spudded.

All four reservoirs were mapped on a scale of 1 inch to 200 feet.

Current velocity and discharge measurements, and examinations of channel bottom conditions were made on 3 navigation channels on the New River above Hinton, W. Va., on May 21 and 22.

## RESERVOIR SEDIMENTATION

### Washington Mills Reservoir

General Information. - The Washington Mills dam and reservoir are owned by the Washington Mills Company, and are used to generate water power for operating their cotton mills at Fries, Va. (Fig. 7). The reservoir was first filled about November 1902, which made its total age to date of survey approximately 33.5 years.

Dam and Power Facilities. - The dam is a gravity-type stone masonry structure. It is approximately 40 feet high, 647.8 feet long, 12 feet wide at the top and 50 feet wide at the bottom. The spillway, which is 514.6 feet long, extends across the top of the dam and is equipped with wooden flashboards which raise the crest 2.36 feet to an elevation of 2187.85 feet above sea level. <sup>3/</sup> Five 4 by 16-foot headgates in the left end of the dam admit water to the canal or forebay leading to the generators. Five similar gates divert water from the canal to the river below the dam when repairs are necessary.

The installed power equipment comprises 3 units, rated at 2,000 kw., 750 kw., and 250 kw., respectively. The operating head under full reservoir is 38 feet. The reservoir is not drawn down below crest level except for occasional repairs.

Original Character of Reservoir Basin. - The original basin was approximately 1.6 miles long with an average width of 600 feet (figs. 7 and 8). The original capacity below damcrest level was 2,954.24 acre-feet. The river channel, almost as wide as the present reservoir, was bordered by tree- and brush-covered slopes. Commonly, the slopes have an incline of about 30 degrees, but vertical and overhanging cliffs extend along the right wall for about a quarter of a mile above the dam. In contrast to the steep slopes, the bottom of the channel was remarkably flat in cross section, despite an average gradient within the limits of the reservoir of 28 feet per mile. The entire original bottom was rocky, being composed of lodges of schist and gneiss with occasional large blocks of rock but with practically no soil or older alluvial deposits.

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<sup>3/</sup> A recheck of the U.S.G.S. benchmark at Fries, Va., shows that 0.11 feet should be added to this elevation to adjust to mean sea level datum.

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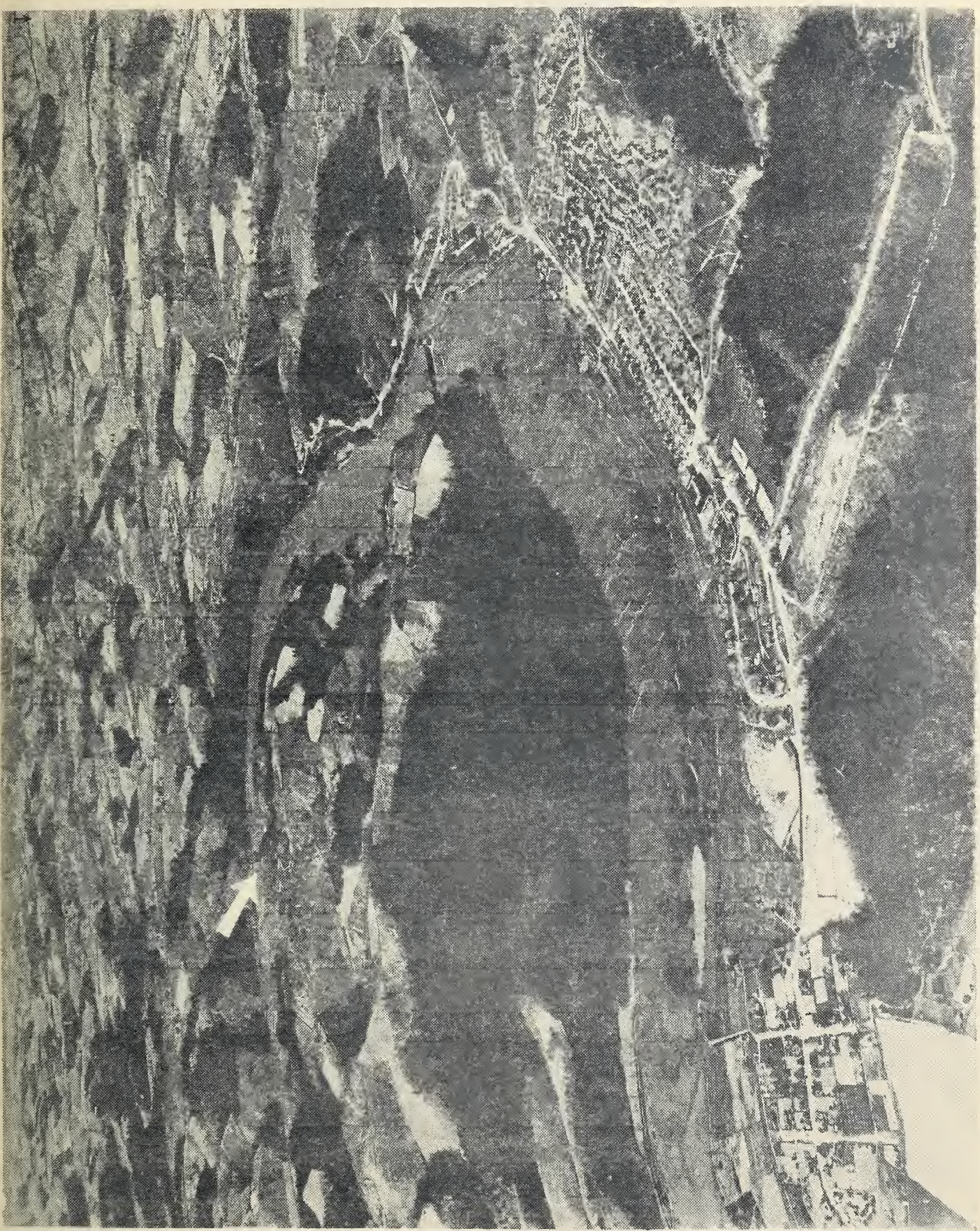
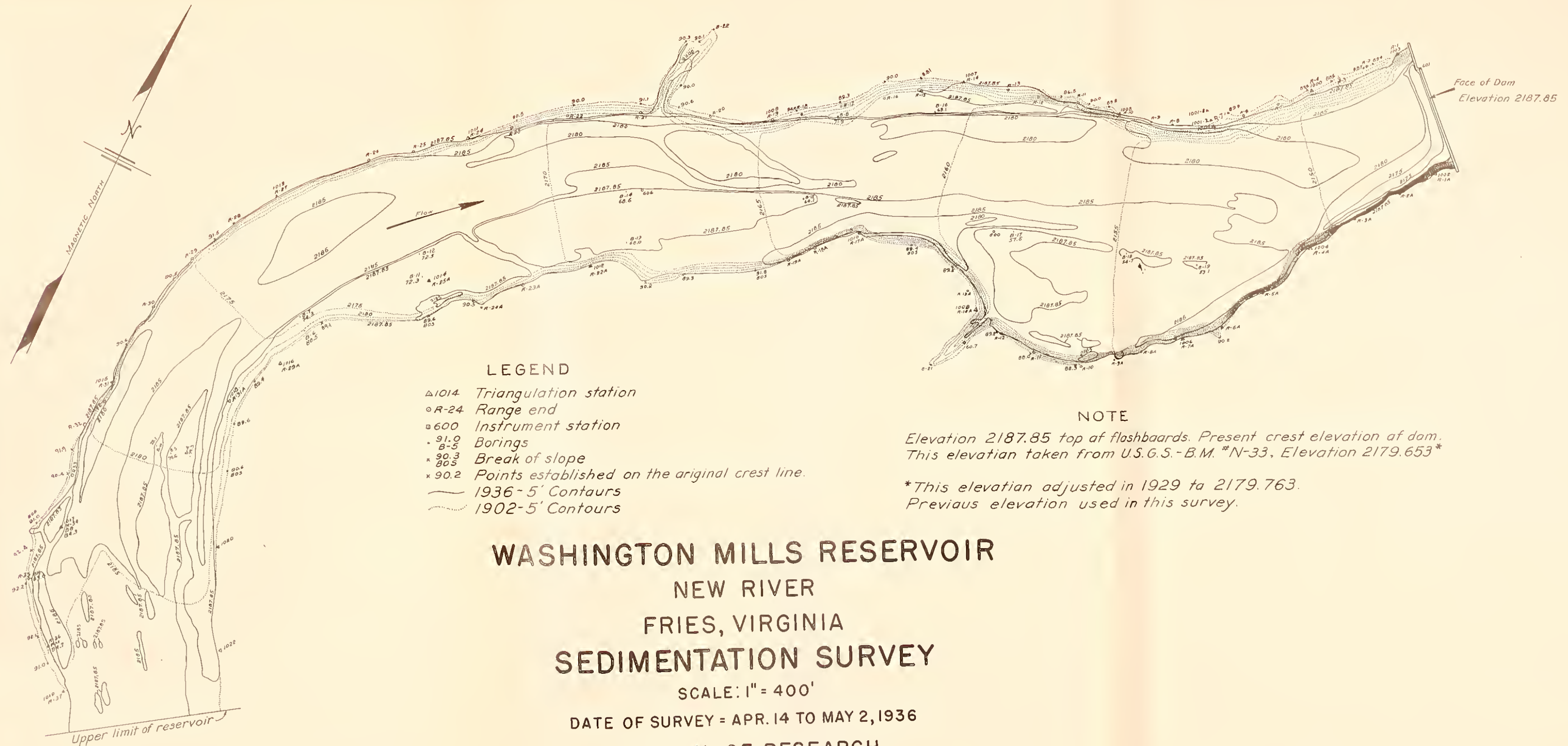


Figure 7. Aerial view of Washington Mills Dam and Reservoir. Arrow indicates head of backwater. Fries, Va., in foreground. (Courtesy of Aerial Surveys of Pittsburgh, Inc.)







Character, Distribution, and Origin of Sediment. - Washington Mills Reservoir contains 2,442.77 acre-feet of sediment, representing 82.69 percent of the original capacity (figs. 9 to 12). The deposits consist of rudely stratified sand and silt, with successive layers of pure silt, sandy silt, silty sand, and relatively clean sand. The upper 1 to 3 feet is generally oxidized to a gray-brown color, below which the prevailing color is dark gray. There is very little difference in the character of sediment found in the upper and lower parts of the reservoir. Much silt was found on bars and islands near and even above the head of backwater, and large quantities of sand were mixed and interstratified with silt near the dam. Traces of gravel on the rock bottom were found in borings near the head of the reservoir (fig. 13).

In general, the sediment in Washington Mills Reservoir increases in thickness from practically zero a few hundred feet below the shoals at the head, to 35 feet or more near the dam. Changes in thickness are very irregular due to the numerous channels, bars, islands, and depressions on the present silt surface. In addition to sediment below the crest contour, numerous bars and islands of silt and sand have been built up as much as 2 feet above crest. Since the total area of these bars and islands is considerable, the quantity of sediment deposited above crest is an appreciable part of the total deposition in the reservoir area.

Excessive silting presents a serious problem to the Washington Mills Company in maintaining continuous operation of their plant at Fries, Va. The storage capacity of their reservoir has been so greatly reduced that they find it necessary to supplement their own generators at intervals by power from the Appalachian Electric Power Company.

Frequent shut-downs are required in order to sluice out the intake to the generators. Silt accumulates so rapidly in the forebay that a mud valve at the lower end, opened in November 1935, was found to be covered with 6 feet of mud when the valve was again opened 5 months later on April 18, 1936 (fig. 12-B). A fire hose is used to hydraulic the silt from the canal above the generators. This process is repeated on an average of 3 or 4 times a year (fig. 14).

Another practice followed by the Washington Mills Company is to open the headgates from the canal to the river below the dam, allowing all the stored water as well as normal discharge to drain out rapidly, washing silt with it. On April 18, 1936, 6.76 acre-feet of silt--equal to 1.32 percent of storage capacity before draw-down, or 23 percent of the original capacity--was flushed from the basin by this process. (figs. 2, 3, and 15). Better results are prevented by the fact that the bottom of the 5 headgates are 20 feet or more above the original stream bed, and are all at one end of the dam. Silt is thus scoured from a single narrow channel extending about 2,000 feet above the dam, and to only about one-half the depth of the deposits, leaving the greater part untouched (fig. 10-B).

The effects of the draw-down are summarized in the following tabulation.



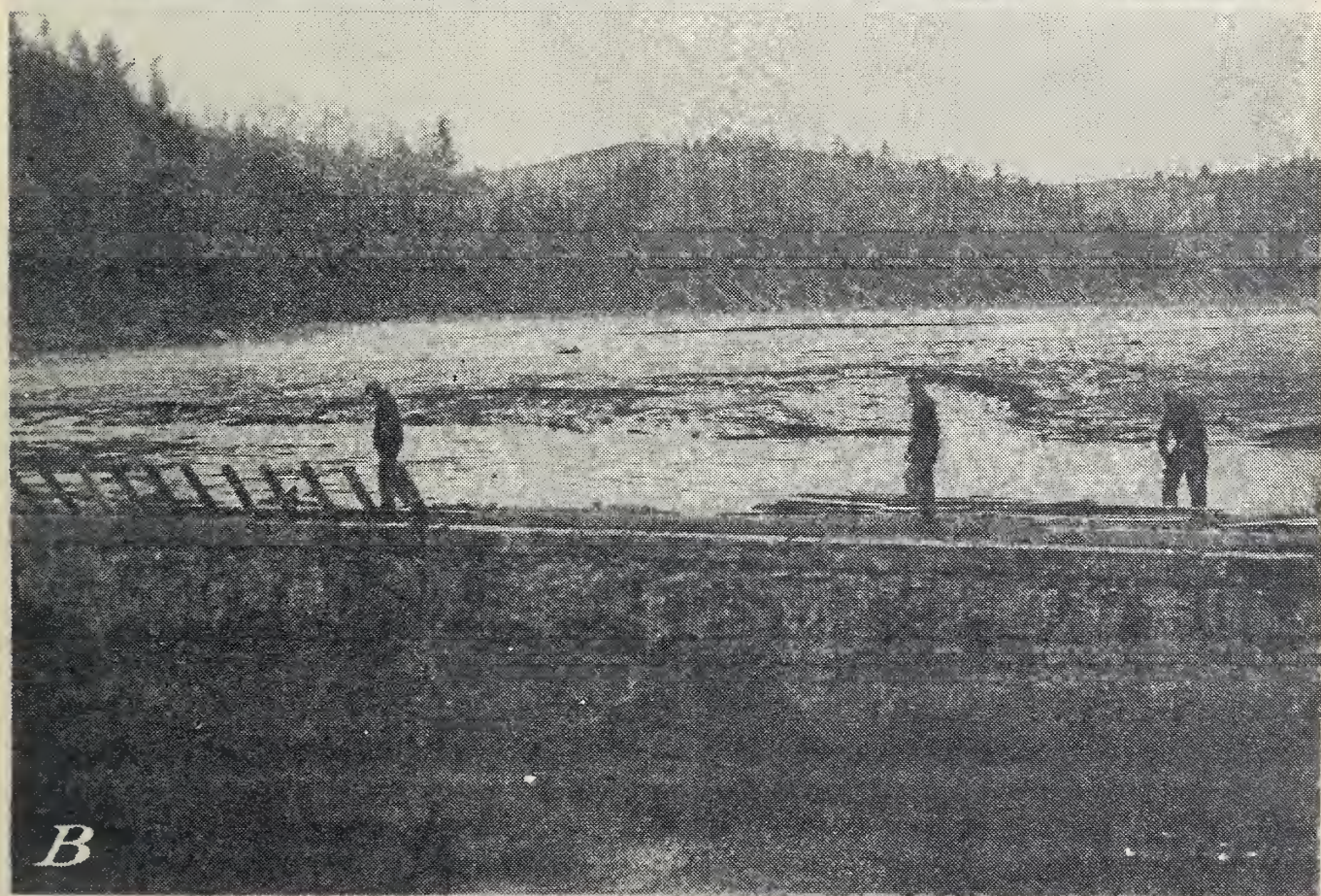
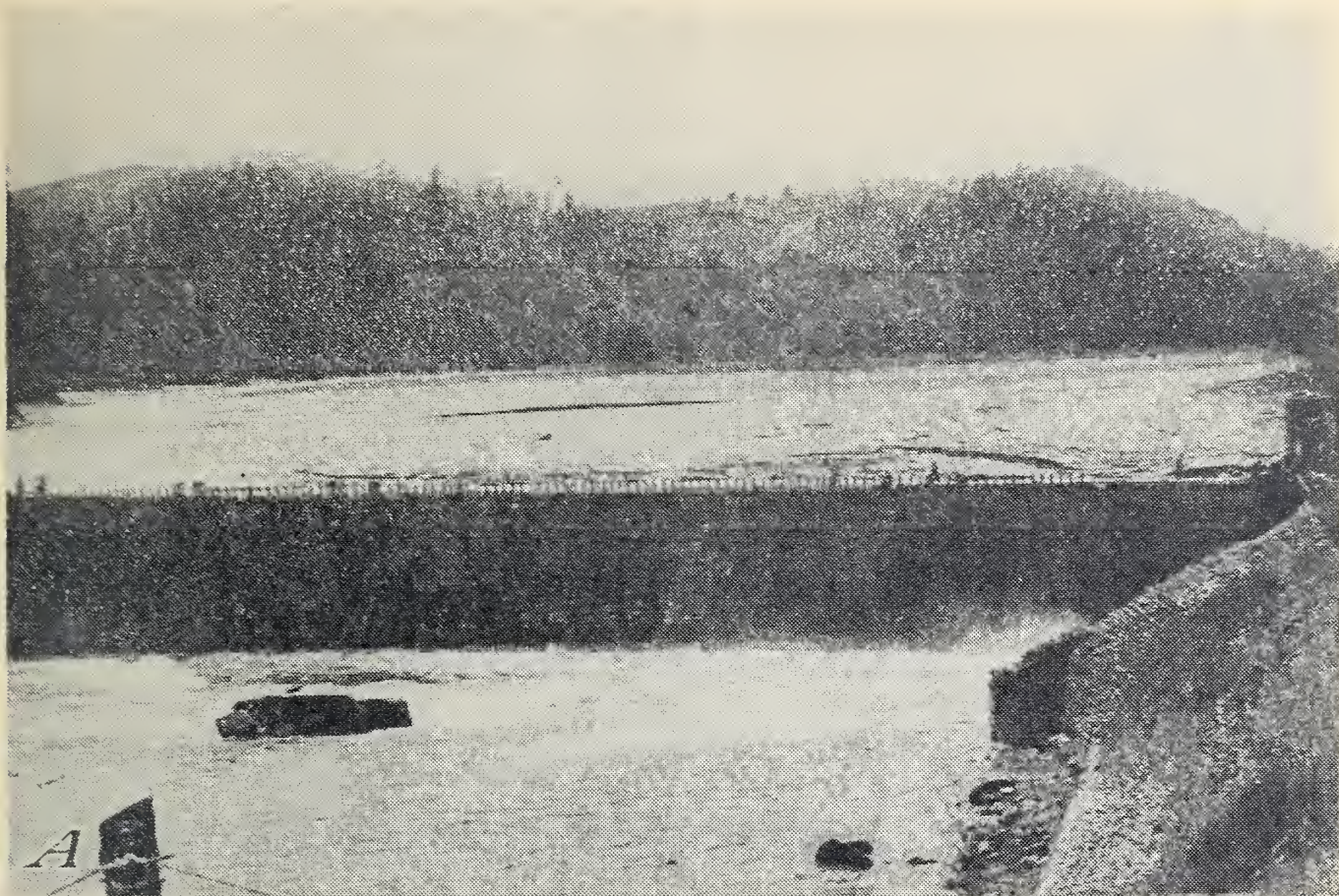


Figure 9.-A. View upstream across Washington Mills Dam during draw-down, showing silt deposits within a few feet of crest level. B. View upstream across Washington Mills Dam, showing silt deposits and channel being cut during draw-down. The current is flowing to the right in the foreground toward the headgates.





Figure 10.-A. View downstream at Washington Mills during draw-down, showing silt deposits just above the dam. B. View of the lower end of Washington Mills Reservoir, showing embayment filled to crest level with silt deposits.



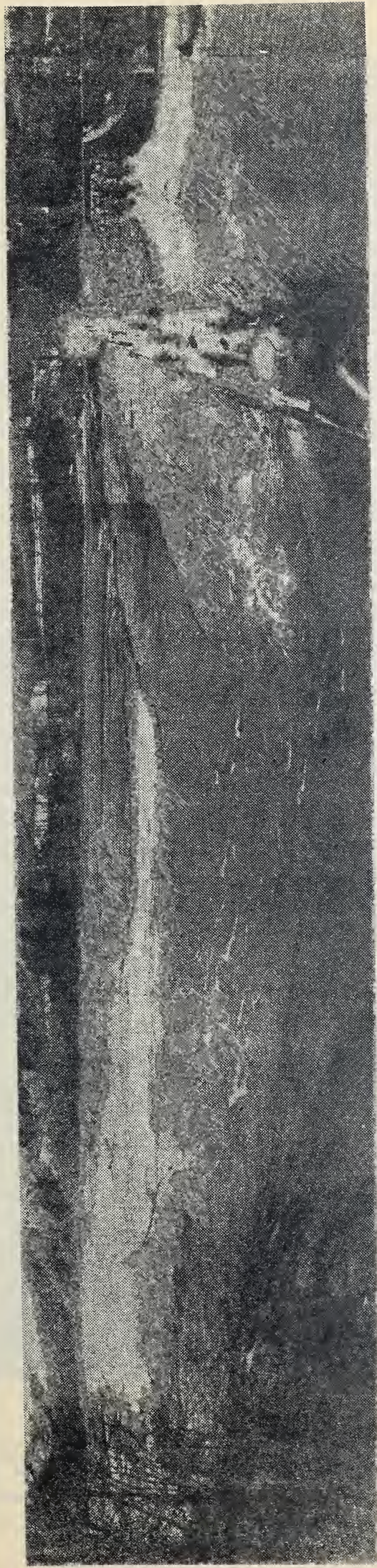


Figure 11. Panorama of Washington Mills Dam and silt deposits, taken while the reservoir was drained for repairs to flashboards.

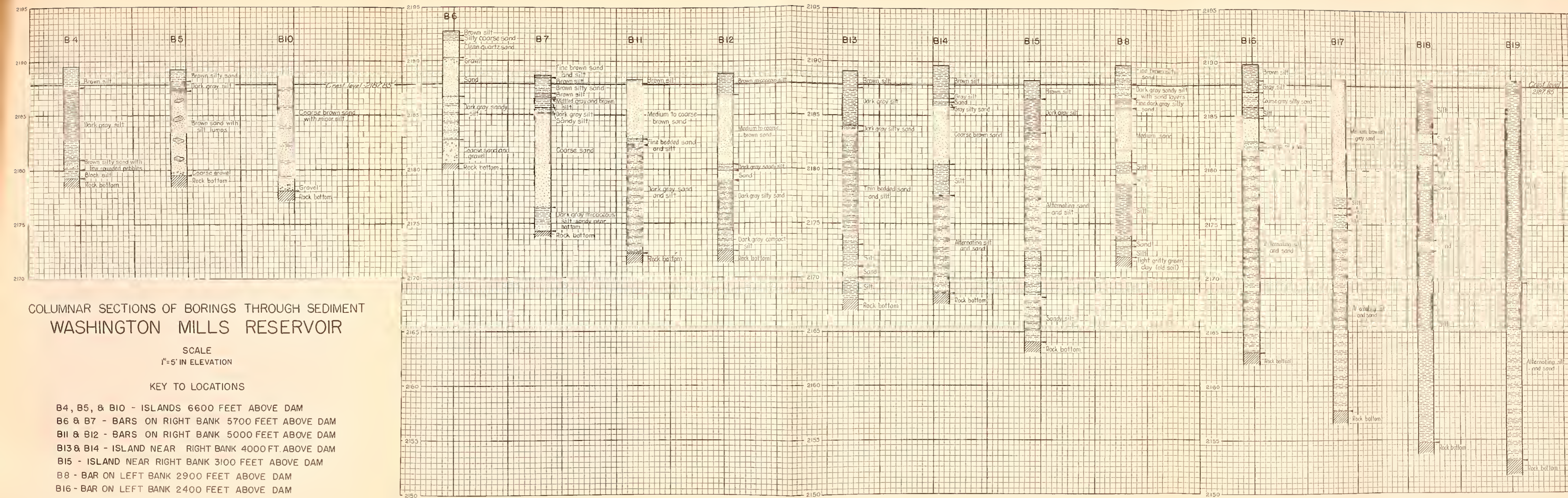
(Courtesy of Aerial Surveys of Pittsburgh, Inc.)





Figure 12.--A. Silt deposits just above the headgates at Washington Mills Dam, showing slumping caused by scour during draw-down. B. View of silt deposits in the forebay at Washington Mills Reservoir.







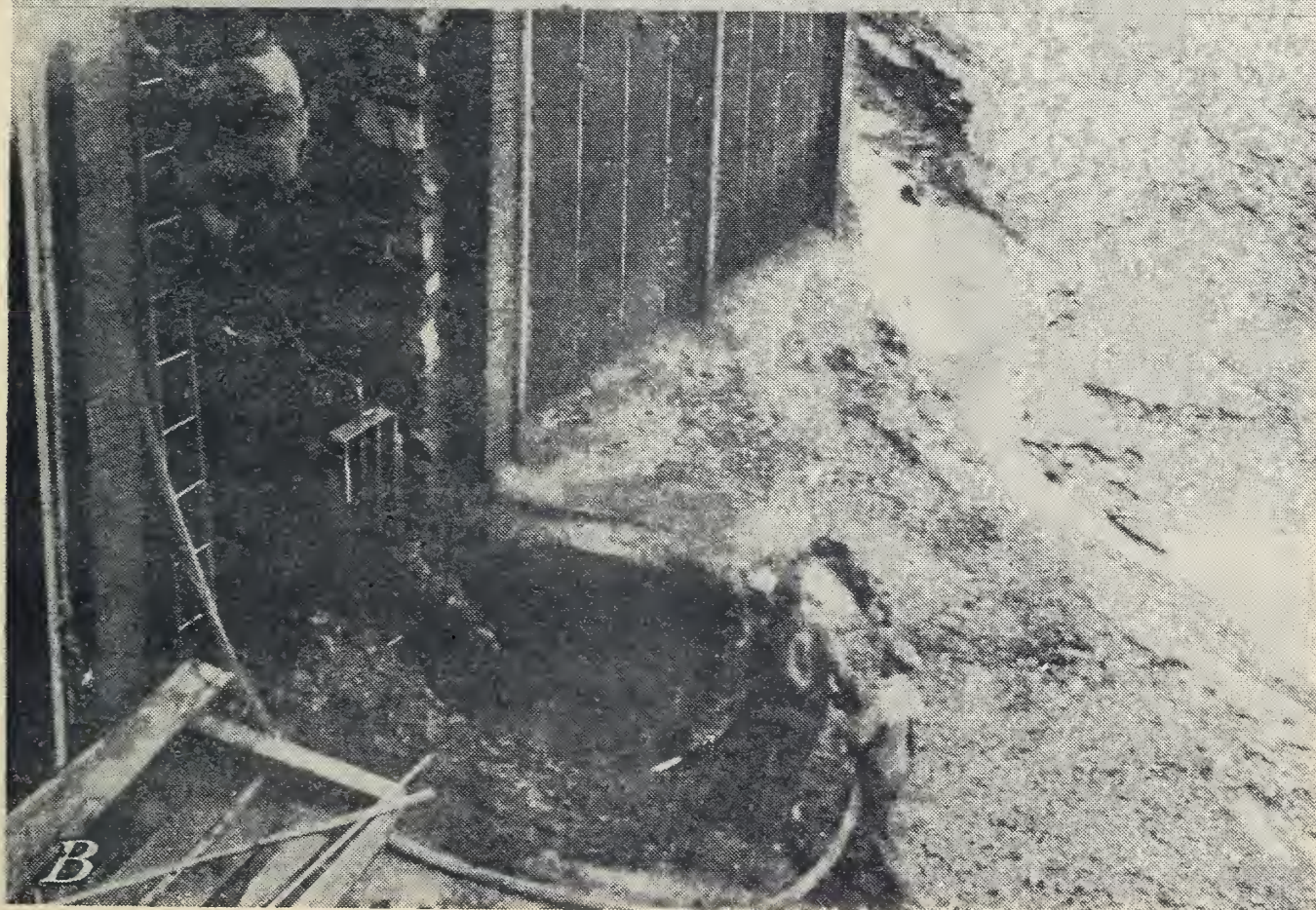
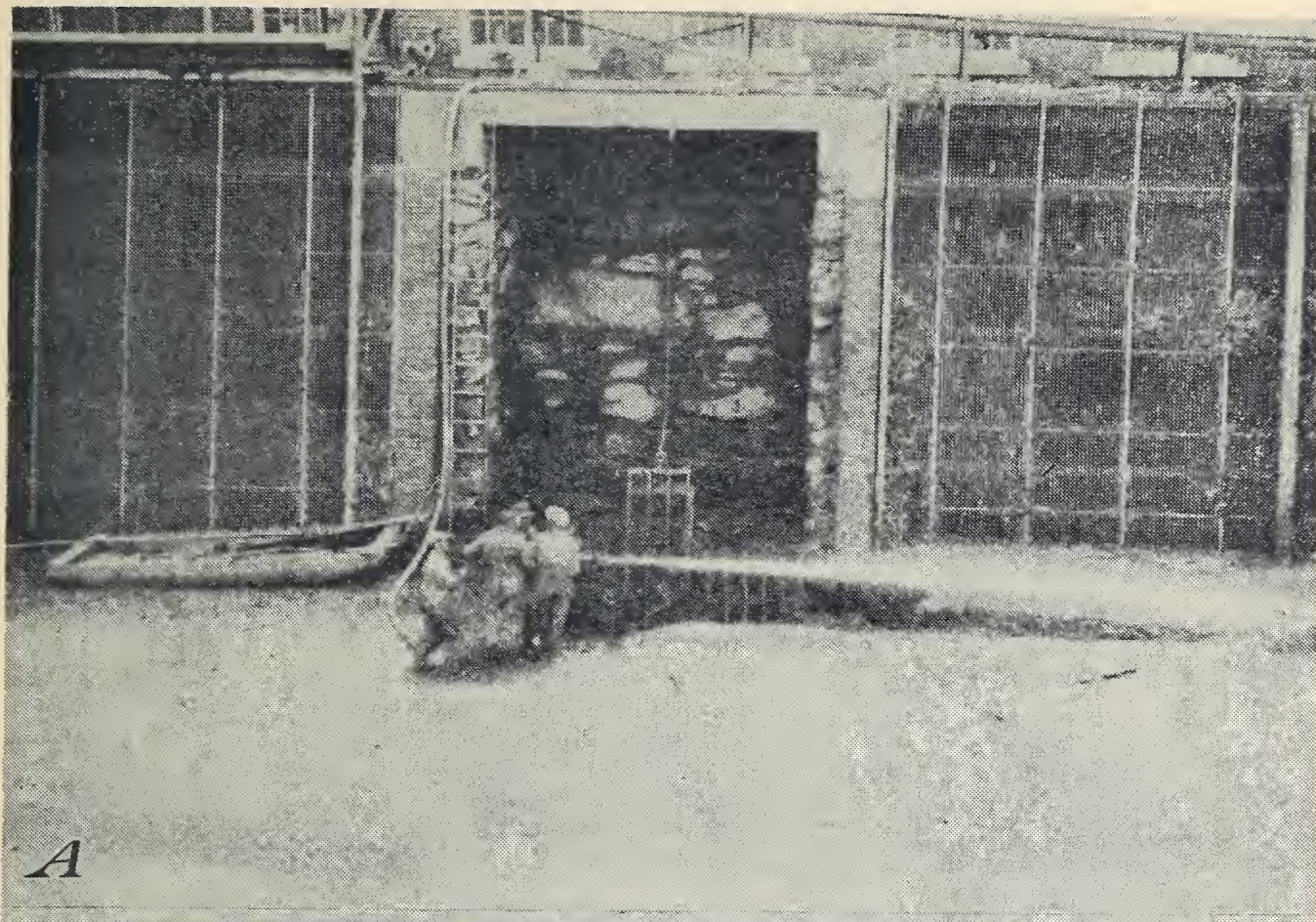
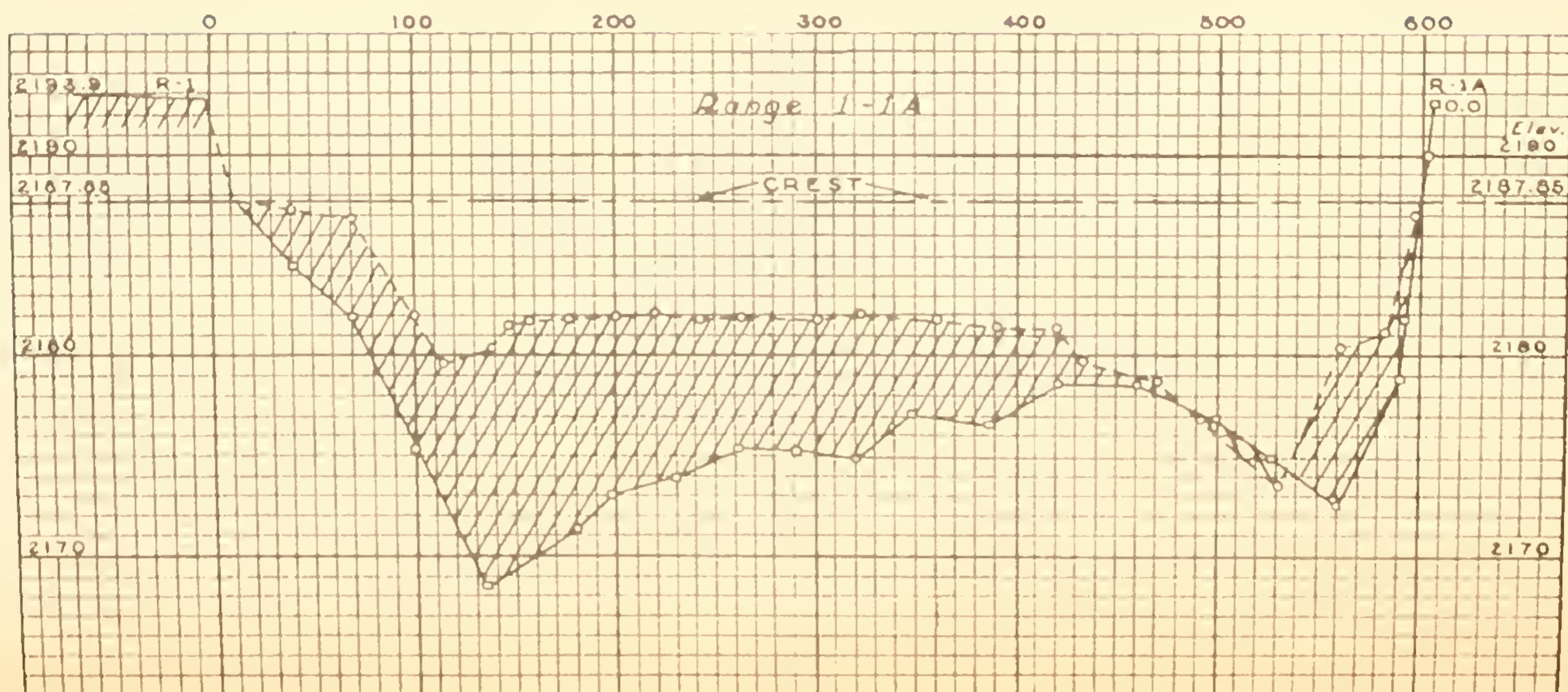


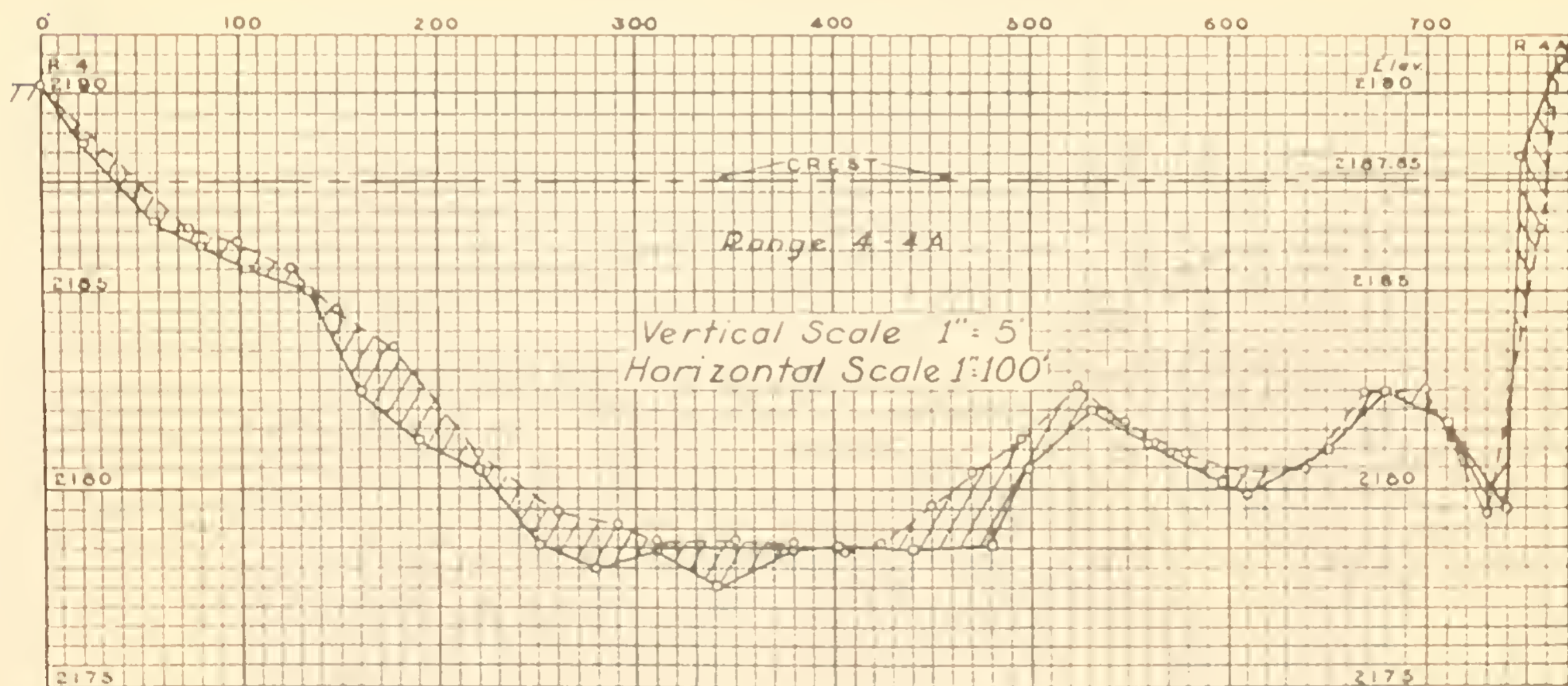
Figure 14.-A. View of foot of forebay at Washington Mills during draw-down, showing workmen hydraulicking silt from the mud valve. Six feet of silt accumulated between November 1935 and April 1936. B. View of foot of forebay at Washington Mills during draw-down, showing silt being hydraulicked from the mud valve.



# CROSS SECTIONS OF WASHINGTON MILLS RESERVOIR FRIES, VA.



*Vertical Scale 1"=10'*  
*Horizontal Scale 1"=100'*



*Vertical Scale 1"=5'*  
*Horizontal Scale 1"=100'*

////// / Wash  
\\\\\\\\\\ Deposition

----- Before drawdown of Lake  
----- After drawdown of Lake

L-344



The figures relative to Washington Mills Reservoir are summarized in the following tabulation.

Statistical summary of data relating to Washington Mills Reservoir, Fries, Va.

<u>Age:</u> <sup>1/</sup> .....	<u>Quantity</u>	<u>Unit</u>
.....	53.5	Years
<u>Reservoir:</u>		
Original area at crest stage.....	150.51	Acres
1922 area at crest stage.....	126.66	do
Present area at crest stage.....	119.71	do
Original storage capacity.....	2,954.24	Acro-feet
1922 storage capacity.....	590.28	do
Present storage capacity.....	511.47	do
<u>Sedimentation:</u>		
Total sediment . 1922.....	2,363.96	Acro-feet
Total sediment . 1936.....	2,442.77	do
Accumulation per year average, 1902-22.....	118.20	do
Accumulation per year average, 1922-36.....	5.84	do
Accumulation per year average, 1902-36.....	72.92	do
<u>Depletion of storage:</u>		
Loss of original capacity per year, 1902-22 :	4.00	Percent
Loss of original capacity per year, 1922-36 :	0.20	do
Loss of original capacity per year, 1902-36 :	2.47	do
Loss of original capacity to date of survey :		
1902-22 :	80.02	do
1902-36 :	82.69	do

<sup>1/</sup> Date storage began; November 1902; date of this survey; May 1936.

Byllesby Reservoir

General Information. - The dam and reservoir are owned by the Appalachian Electric Power Company for the operation of their hydro-electric plant at Byllesby, Va. ( fig. 16). The reservoir was first filled in August 1912 so that the total age to date of survey is 23.66 years.

Dam and Power Facilities. - The dam is of gravity type and is constructed of reinforced concrete surmounted by steel tainter gates and wooden flashboards. The main dam is 680 feet long, including powerhouse, 61 feet wide at the base with ogee section, and 44 feet high from the average level of original river bottom to the top of the concrete. A low spillway dam of reinforced concrete in the left abutment is 198 feet long, 20 feet wide, and 10 feet high, and makes an angle of





Figure 16. Aerial view of Byllesby plant and reservoir. Crooked Creek enters from the left. (Courtesy of Aerial Surveys of Pittsburgh, Inc.)



100° 12' with the main dam. Six spans of taintor gates with a total length of 206 feet, and 9 spans of flashboards totaling 298 feet, raise the crest 8.3 feet to an elevation of 2,087.3 feet above mean sea level (local datum), and increase the total height of the dam to 52.3 feet. Wooden flashboards on the spillway dam raise its crest to approximately the same level.

The installed power equipment includes 4 units rated at 6,000 kv-a. each, with a total plant capacity of 18,000 kw. The operating head under full reservoir is 57.6 feet. The average daily draw-down below crest level is 1 foot, and the draft under full plant operation with full reservoir is 5,440 cubic feet per second.

Original Character of Reservoir Basin. - The original basin was a gently winding channel 3.4 miles long, ranging in width from 600 to 900 feet (fig. 4). Crooked Creek, which enters the main channel from the right 3,500 feet above the dam, forms a narrow arm 1.3 miles long and 200 to 300 feet wide with a sharp hairpin bend midway of its length. The original storage capacity of the reservoir below dam crest level was 8,892.16 acre-feet.

The valley slopes are entirely wooded. Those of the right shore are extremely steep with numerous rocky cliffs, whereas those on the left shore are moderately steep and even. The original bottom was a succession of rocky shoals, with flat cross section and a gradient averaging 15.6 feet per mile. No older alluvial deposits were found in the 15 borings made, the bottom in each case being large boulders or bedrock.

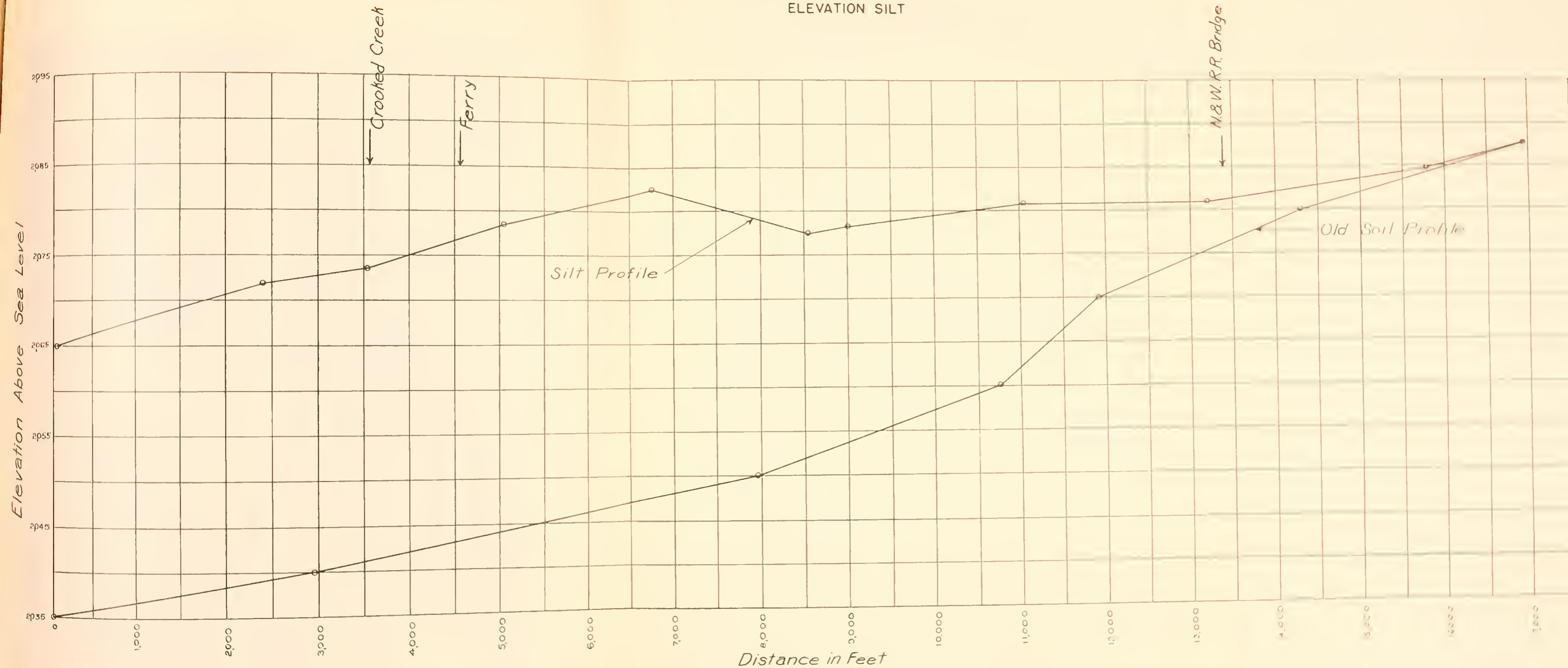
Character, Distribution, and Origin of Sediment. - Byllesby Reservoir has received a total of 5,353.81 acre-feet of sediment, entailing a loss of 60.21 percent of the original capacity. The deposits consist of fine-to medium-grained sand and dark-gray silt, with a brownish tinge in the upper layers. The sediment in the upper part of the reservoir is roughly stratified, the layers consisting of mixtures of silt and sand in all proportions. Near the dam the sediment is thicker and less stratified. A boring 2,000 feet above the dam showed nearly 17 feet of fine silt underlain by compact sand. The silt near the dam is brownish gray, very soft near the surface, and contains much organic material. The sediment on Crooked Creek consists of variable mixtures of silt and sand.

Since silt volume determinations were made by the contour method, the only direct measurements of thickness were obtained from 15 scattered borings, distributed along the main reservoir channel and Crooked Creek, the only important tributary. In general, the thickness of sediment increases toward the dam (fig. 17). In the upper one-half mile of the reservoir, thicknesses of 3 to 5 feet are common, though in some instances the channel on the outside of bends is free of sediment. On the other hand, bars and islands are common on the inside of bends (fig. 18). At a point 2,000 feet above the dam, a boring 26.7 feet deep failed to reach original bottom. Data on the original and present elevations of the bottom just above the dam indicate a maximum thickness of sediment of 30 feet. The contours of the present bottom show elongated ridges



# LONGITUDINAL PROFILE OF BYLLESBY RESERVIOR

SHOWING: ELEVATION OLD SOIL  
ELEVATION SILT



Note: Silt profile plotted from cross section - average depth against distance  
Old soil profile plotted from original contours on base map





Figure 18. Aerial view of the upper end of Byllesby Reservoir, showing silt bars and islands. (Courtesy of Aerial Surveys of Pittsburgh, Inc.)



and channels parallel to the shore line, indicating that deposition was influenced by current action to within a few feet of the dam.

Most of the sediment deposited in Byllesby Reservoir has passed over Washington Mills Dam; hence its original source has been the watershed above Washington Mills Reservoir. A smaller but indeterminate quantity has come from local drainage areas tributary to the river along the 9 mile reach that intervenes between the two dams.

The significant data on Byllesby Reservoir are summarized in the following tabulation:

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Statistical summary of data relating to Byllesby Reservoir,  
Byllesby, Va.

---

	Quantity	Unit
Age: <sup>1/</sup> .....	23.66	Years
Reservoir:		
Original area at crest stage.....	340.53	Acres
Present area at crest stage.....	334.646	do
Original storage capacity.....	8892.16	Acre-feet
Present storage capacity.....	3538.35	do
Sedimentation:		
Total sediment.....	5353.81	Acre-feet
Accumulation per year average.....	226.28	do
Depletion of storage:		
Loss of original capacity per year.....	2.54	Percent
Loss of original capacity to date of survey.....	60.21	do

---

<sup>1/</sup> Date storage began, August 1912; date of survey, May 1936.

---

### Buck Reservoir

General Information. - Buck Dam was constructed in August 1912 by the Appalachian Electric Power Company for the operation of a hydroelectric plant 3.2 miles below Byllesby, Va. (fig. 19). The total age of the reservoir to date of survey is 23.66 years.

Dam and Power Facilities. - The main dam is constructed of reinforced concrete and has a length of 1,004.8 feet, an average width of 22.5 feet, and an average height of 14.4 feet. The concrete is surmounted by wooden flashboards and 6 steel taintor gates which raise the crest level 7.8 feet



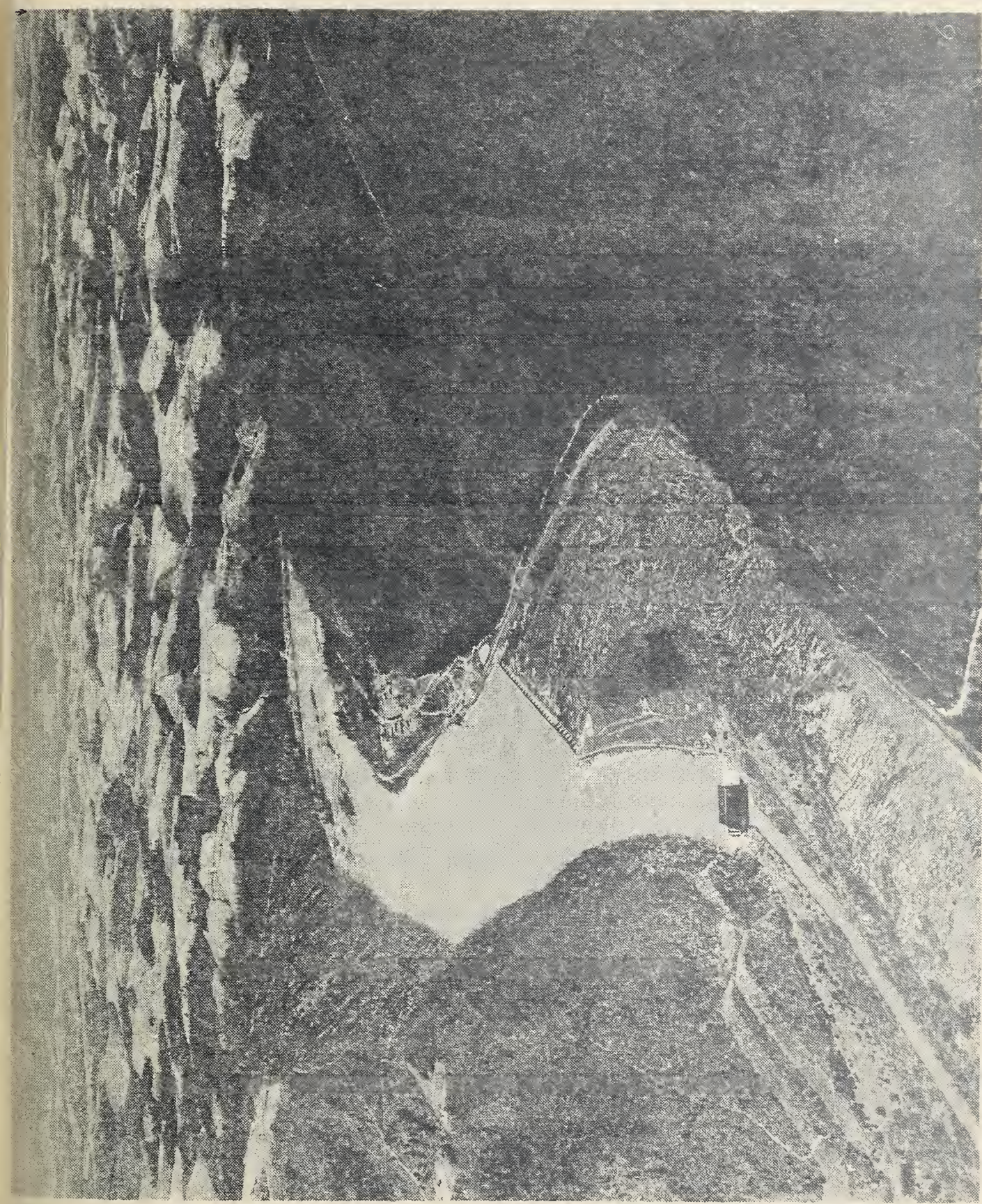


Figure 19. Aerial view of Buck plant and reservoir. Note the silt bars on the right bank and at the head of the forebay. (Courtesy of Aerial Surveys of Pittsburgh, Inc.)



to an elevation of 2,010.4 feet (local datum). The total length of the 6 spans of taintor gates is 165 feet. The power-house is located at the lower end of a forebay 1300 feet long and 300 feet wide, with head at the right end of the main dam. The total length of the power-house and supplementary dam is 280 feet.

The installed power equipment includes 3 units rated at 3,500 hp. each, with a total plant capacity of 9,000 kw. The operating head under full reservoir is 34 feet. The average daily draw-down is 1 foot below fixed crest, and the draft under full plant operation is 3,510 cubic feet per second.

Original Character of Reservoir Basin. - Buck Reservoir has a total length of 5600 feet, including forebay, and a maximum width of 1,000 feet. It occupies little more than the original stream channel (fig. 5). The original capacity below dam crest level was 1,225.33 acre-feet. The slopes on the right hand side are extremely steep and rugged and although heavily wooded, largely consist of bare rock. The average slope of this wall is about 40°. The left hand slope is less steep, with remnants of an old river terrace on which the settlement of Buck Station is situated. The original floor of the basin was on bare ledges of schist and gneiss, and had a flat cross section characteristic of the New River and a gradient of 22 feet per mile.

Character, Distribution, and Origin of Sediment. - The sediment in Buck Reservoir has a total volume of 283.82 acre-feet, representing 23.16 percent of the original capacity. It consists of dark gray silt, sand, and fine gravel. The greatest thickness, up to a maximum of 12.9 feet, was found in the forebay (fig. 20) leading to the power-house, where the deposits consist almost entirely of silt. Above the main dam (figs. 21 and 22) a layer of 1 to 3 feet of sand is overlain by 3 to 6 feet of silt, with considerable mixing and interstratification. As the head of backwater is approached, the sediment decreases in thickness and becomes more and more sandy, and the sand becomes coarser in texture. Very little sediment of any kind was found within 1,500 feet of the head of backwater.

Sediment entering Buck Reservoir has been concentrated in the forebay and in a large bar on the left shore extending between points 800 and 1,500 feet above the end of the main dam. Other parts of the basin are floored by a blanket of 2 to 3 feet of silt and sand, except near the head of backwater where currents have kept the rock bottom free of sediment.

Sediment entering Buck Reservoir comes largely from the overflow of Byllesby Reservoir 3 miles upstream. The quantity derived from the rocky wooded slopes in the intervening stretch of river is negligible. The following tabulation summarizes sedimentation in Buck Reservoir:



# CROSS SECTIONS OF BUCK RESERVOIR IVANHOE, VA.

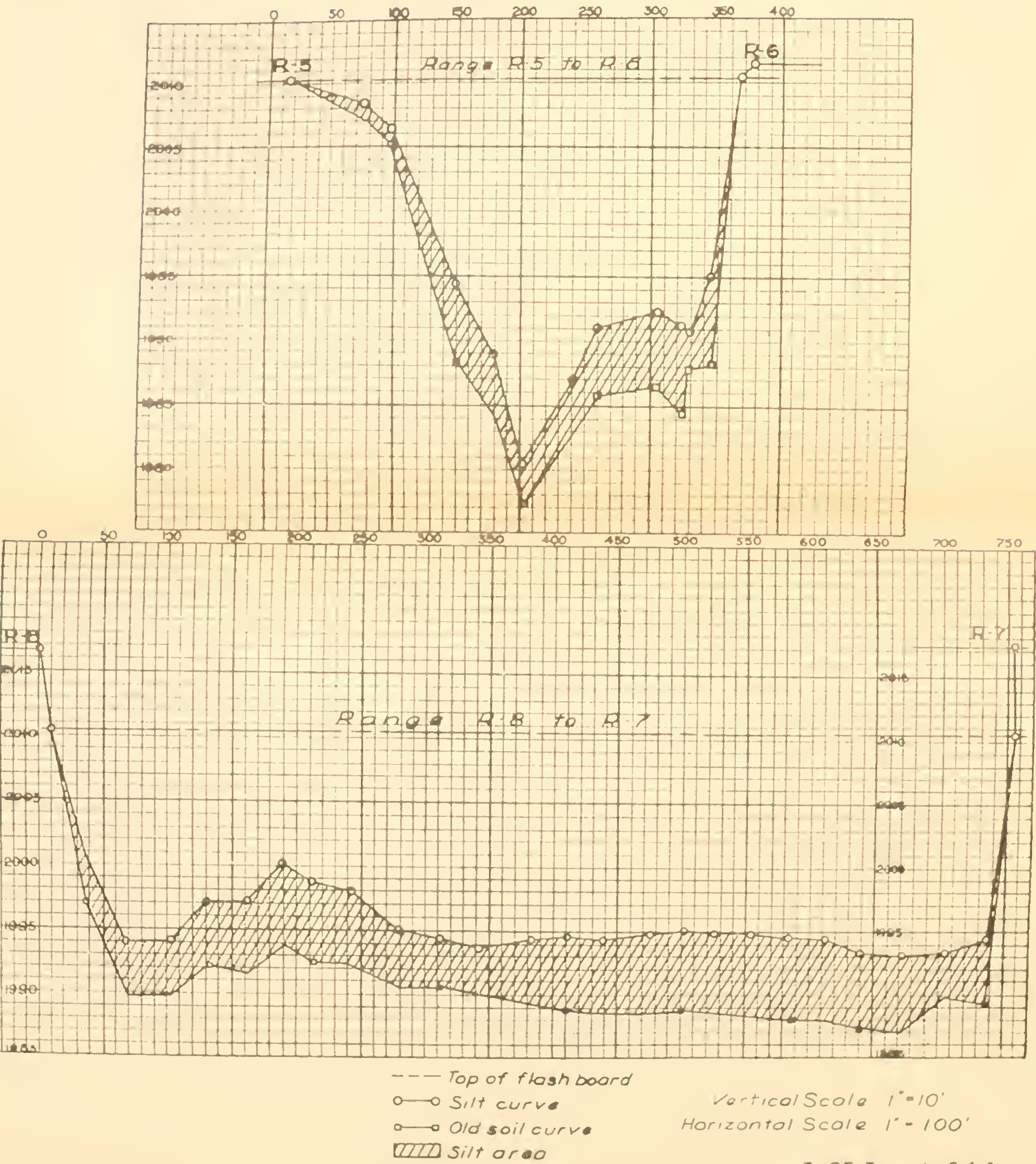


Vertical Scale: 1" = 10'  
Horizontal Scale: 1" = 100'



Fig. 21

CROSS SECTIONS OF  
BUCK RESERVOIR  
IVANHOE, VA.

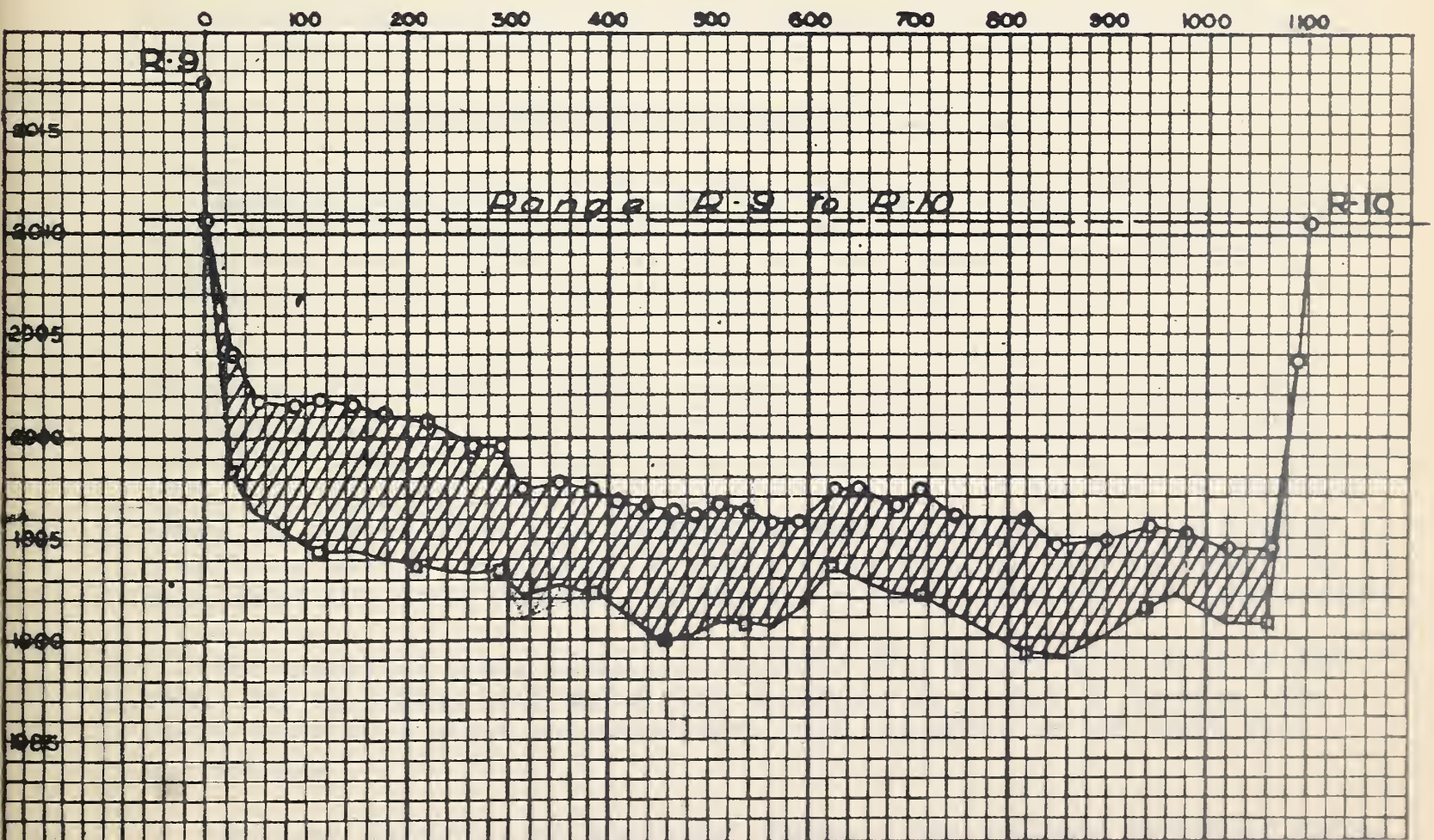




# CROSS SECTIONS OF BUCK RESERVOIR IVANHOE, VA.

--- Top of flash board  
 o—o Silt curve  
 □—□ Old soil curve  
 ▨ Silt area

Vertical Scale: 1"=10'  
 Horizontal Scale: 1"=200'





Statistical summary of data relating to Buck Reservoir, Ivanhoe, Va.

	Quantity	Unit
Age: <u>1/</u> .....	23.66	Years
<u>Reservoir:</u>		
Original area at crest stage.....	92.83	Acres
Present area at crest stage.....	92.83	do
Original storage capacity.....	1,225.33	Acro-foot
Present storage capacity.....	941.51	do
<u>Sedimentation</u>		
Total sediment.....	283.82	Acro-foot
Accumulation per year average.....	12.00	do
<u>Depletion of storage:</u>		
Loss of original capacity per year.....	0.98	Percent
Loss of original capacity to date of survey.....	23.16	do

1/ Date storage began, August 1912; date of this survey, May 1936.

Fields Manufacturing Company Reservoir

General Information. - The dam is owned by the Fields Manufacturing Company, and furnishes head for generating power to operate their woolen mills near Mouth of Wilson, Va. The dam was completed in August 1930, making the total age to date of survey 5.75 years.

Dam and Power Facilities. - The dam is a concrete gravity-type structure with an ogee section, and has a total length of 420 feet and a height above river bed ranging from 7 to 14 feet. The latter was increased 10 inches by placing boards on top of the concrete in the spring of 1935. The spillway, which extends across the top of the dam, is 354 feet long. An 8-foot flood gate between the dam and spillway also serves as a spillway with a crest about 6 inches lower than the main spillway. The main crest was used, however, as the controlling elevation for this survey.

The installed power equipment consists of a single unit rated at 125 kw-a. The operating head under full reservoir is 8 feet 10 inches. The draft under full plant operation with full reservoir is 193 cubic feet per second.

Original Character or Reservoir Basin. - The original reservoir basin had an average width of 300 feet and a total length below the crest contour of 1.3 miles, with the general outline of a gently winding stream channel (fig. 6). The original capacity below crest level was 183.81 acro-foot. The original reservoir, which was confined to the banks of the main channel,



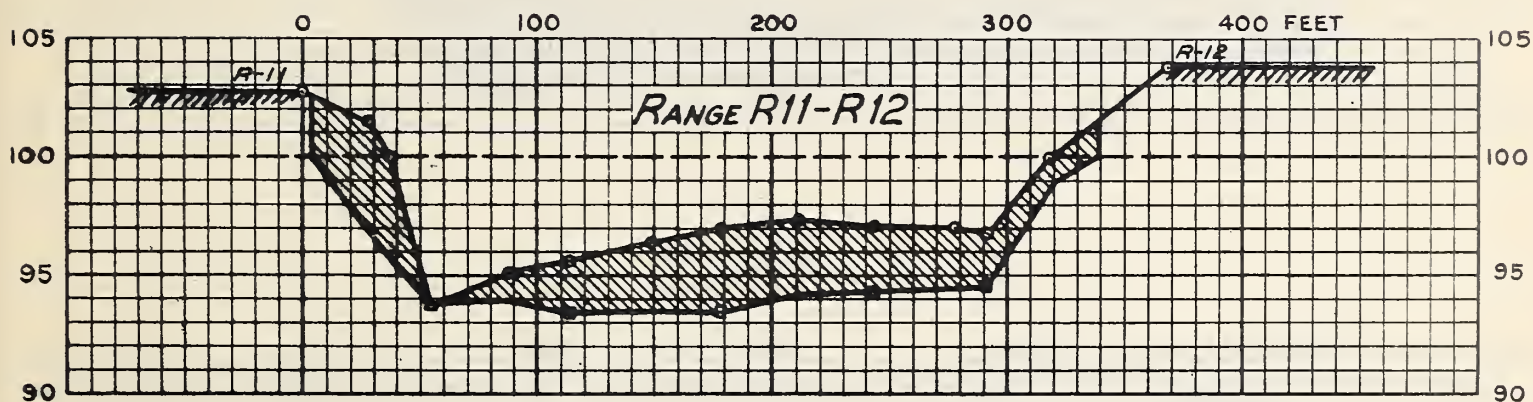
was bordered by strips of cultivated bottomlands with sloping and gently rolling surface, composed of bars of sand and silt deposited earlier in the stream's history. These rolling flood plains extend along practically the entire length of the right bank, and range in width from 200 to 600 feet, with greatest width on the inside bends of the river. Similar bottomlands extend along the left bank from midlength to the head of backwater, with widths ranging from 100 feet along straight reaches to 600 feet on the inside of the second bend above the dam. These bottomlands have been widened from 10 to 50 feet by post-lake deposits of sand and silt. The valley walls rise abruptly from the edge of the bottomlands, and are entirely wooded with numerous slopes of 20° to 30°. The original stream bed was rocky, and had the flat cross-section characteristic of the New River. The fall within the reservoir area averages approximately 6 feet per mile.

Character, Distribution, and Origin of Sediment. - A total of 74.59 acre-feet of sediment was present in Fields Reservoir at the time of survey. This volume represents 40.58 percent of the original capacity. The sediment consists almost entirely of sand. Silt occurs in small quantities in lower sand layers near the dam, and also in the bars built up along both shores in the lower part of the lake. The sand shows a wide range in texture, being very fine near the dam, and increasingly coarse toward the head of backwater. It is apparent that a dam as low as the one at this point has little effect in stopping the sediment being carried by the New River. Practically all the silt and most of the sand washed into the reservoir basin has either gone over the dam or has stopped only temporarily. The type and quantity of sediment now present indicates that sedimentation conditions are little different from those which exist in an exceptionally deep pool above a natural shoal. A large part of the sand now in the reservoir, therefore, represents the normal bedload of the stream (figs. 23 and 24).

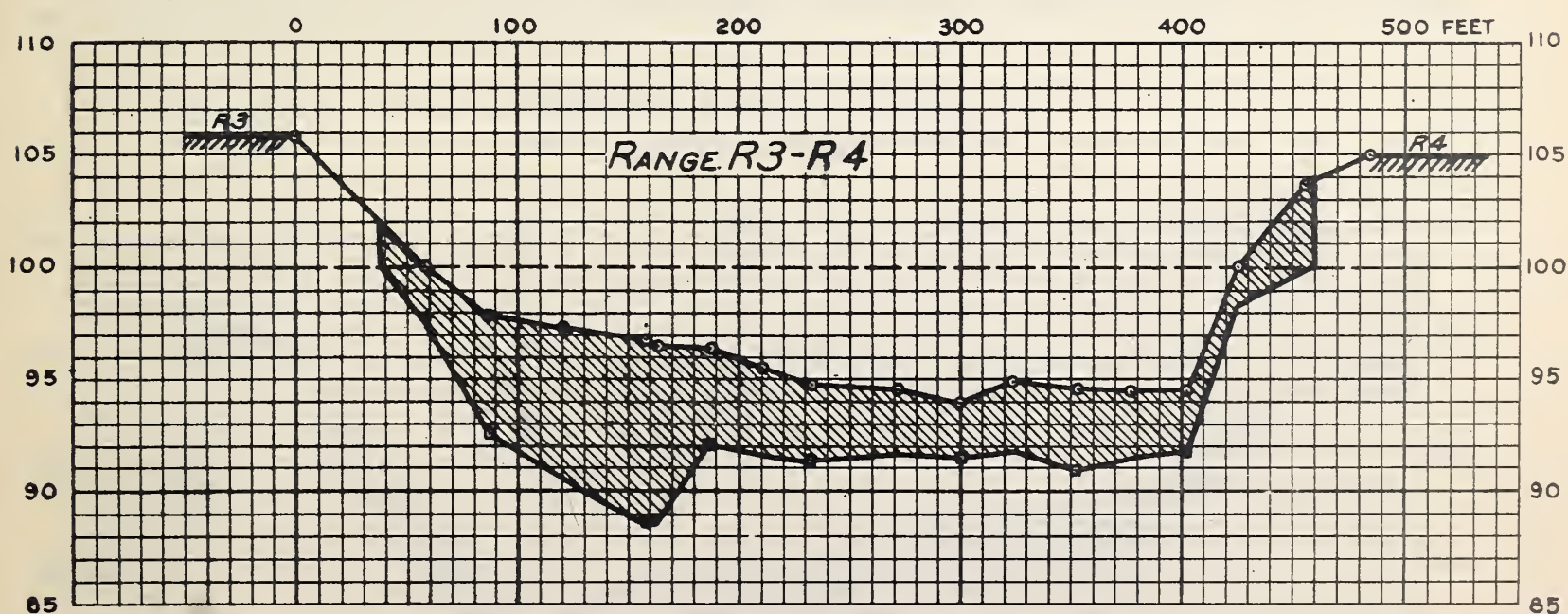
The pertinent data on Fields Reservoir are given in the following tabulation:



# CROSS SECTIONS OF FIELDS MANUFACTURING CO. LAKE INDEPENDENCE, VA.



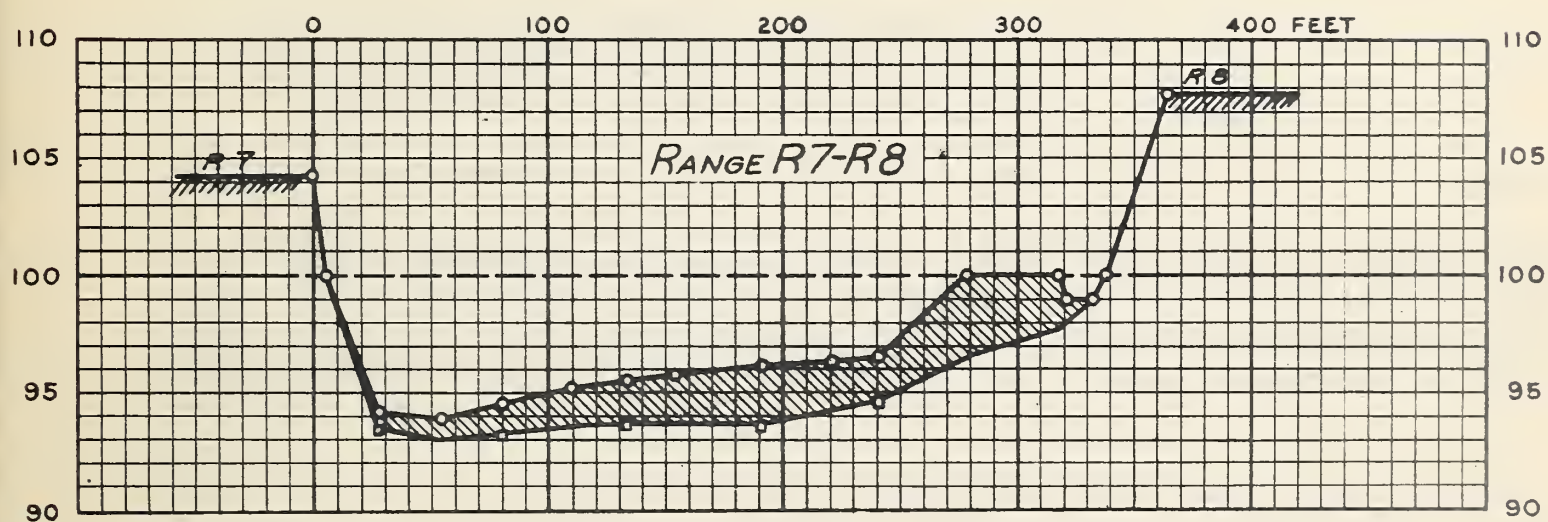
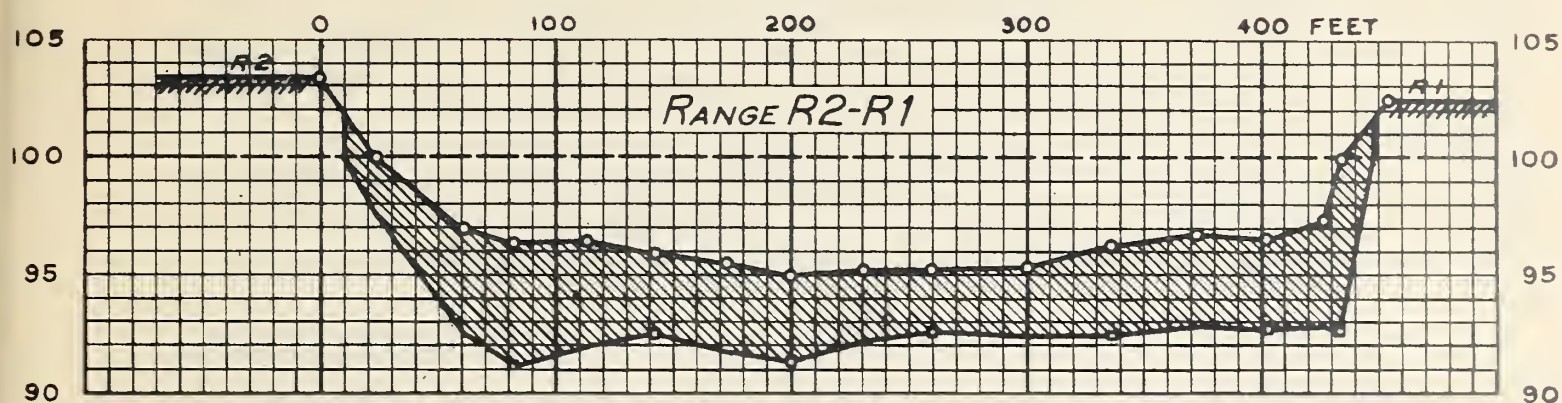
*Vertical scale: 1" = 10'*  
*Horizontal scale: 1" = 100'*



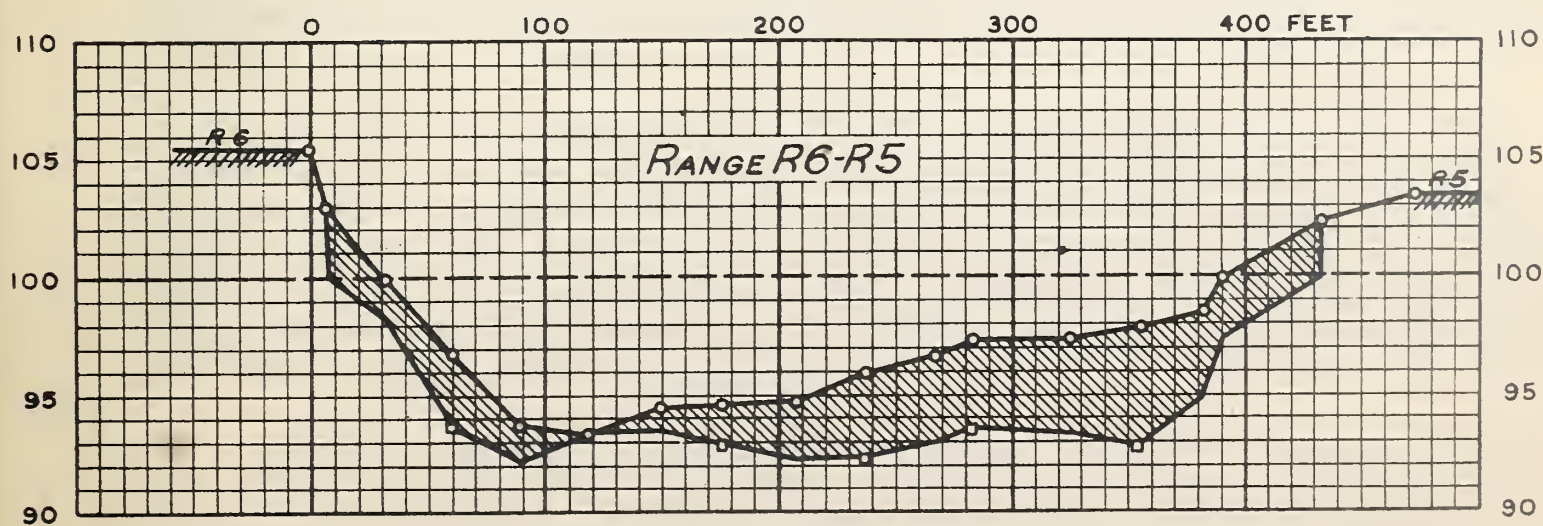
--- = Top of flash-board  
 ●—● = Silt Curve  
 □—□ = Old Soil Curve



# CROSS SECTIONS OF FIELDS MANUFACTURING CO. LAKE INDEPENDENCE, VA.



*Vertical scale: 1"=10'*  
*Horizontal scale: 1"=100'*



- - - = Top of Flash-board  
 ● — ● = Silt Curve  
 ■ — ■ = Old Soil Curve



Statistical summary of data relating to Fields Manufacturing Company Reservoir, Mouth of Wilson, Va.

<u>1/</u>	Quantity	Unit
Age: .....	5.67	Years
Reservoir:		
Original area at crest stage.....	46.11	Acres
Present area at crest stage.....	42.05	do
Original storage capacity.....	183.81	Acre-feet
Present storage capacity.....	109.22	do
Sedimentation:		
Total sediment.....	74.59	Acre-feet
Accumulation per year average.....	13.16	do
Depletion of storage:		
Loss of original capacity per year.....	7.16	Percent
Loss of original capacity to date of survey.....	40.58	do

Minor Reservoirs and Mill Ponds. - Although detailed surveys were made only of four reservoirs on the New River, general observations and measurements on several smaller dams and mill ponds on tributary streams added considerably to the general picture of silting conditions in the New River watershed.

A striking example is Poplar Branch Dam, on a small tributary of the New River, just south of Jackson's Ferry on the Carroll-Wythe county line, Virginia. In March 1936 this small concrete dam, about 15 feet high, washed out around one abutment down to the level of bedrock (fig. 25a), exposing a complete section of the silt deposits (fig. 25b). The deposits were found to have been built up practically to the crest level of the dam except for a narrow channel about 12 feet wide and said to have been 12 feet deep at the dam.

An older and smaller dam had existed since 1901 just above the concrete dam, and had completely filled with sediment many years ago. However, most of this older silt was scoured out when the low dam washed away in March 1935. The concrete dam was constructed immediately thereafter so that the present silt is the accumulation of a single year. The deposits were well stratified and consisted chiefly of coarse sand, gravel, and some sawdust with silt-binder.

Several small mill dams, west of Galax, Va., show various degrees of silting according to their age. A small dam on Wilson Creek near its mouth, 15 miles southwest of Independence, Va., estimated to be 10

1/ Date storage began, August 1930; date of Survey, May 1936.



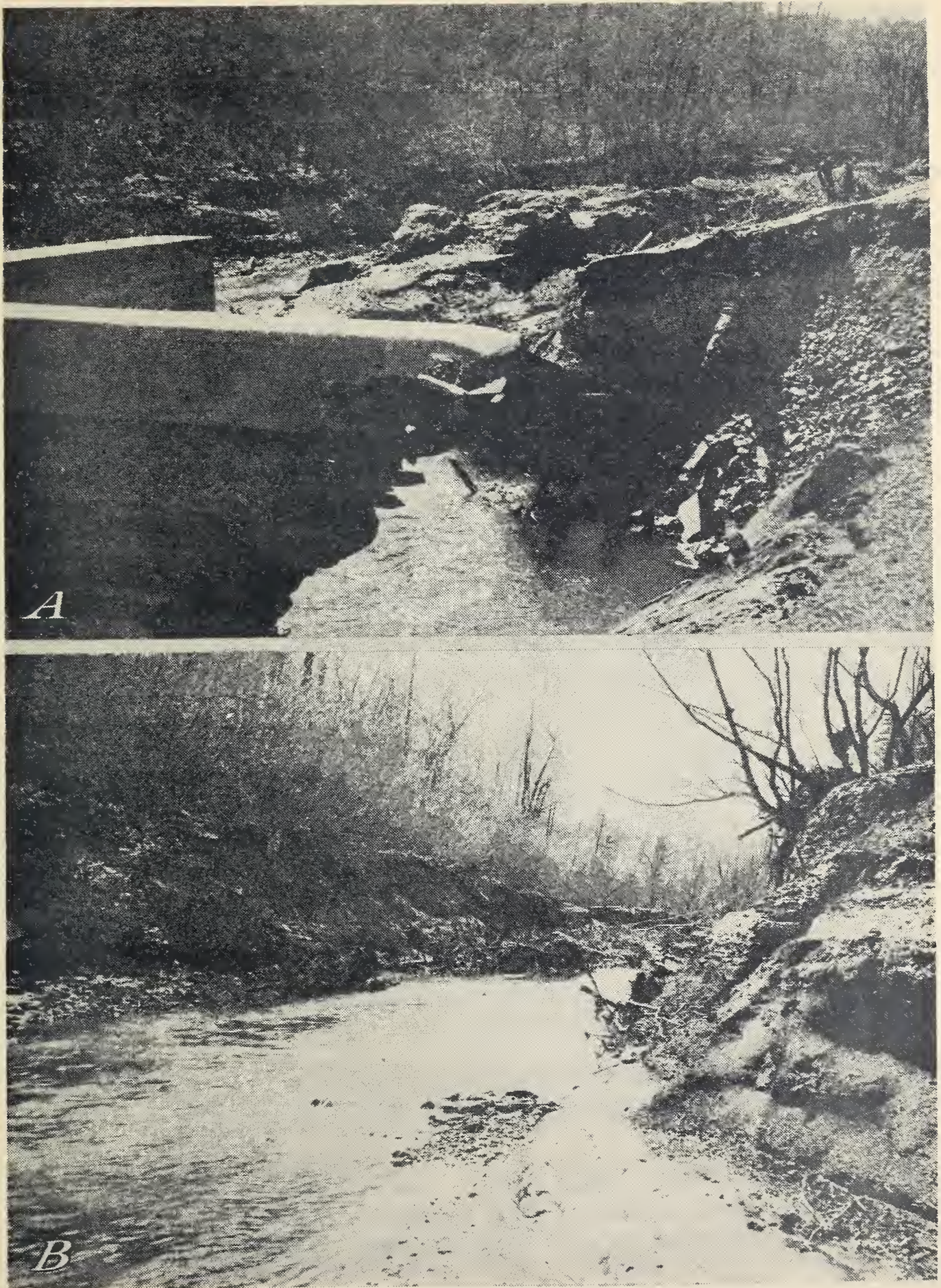


Figure 25.A. View of break in Poplar Branch Dam, south of Jackson's Ferry, washed out in March 1936. B. View of silt deposits above Poplar Branch Dam, and the channel cut following the break of March 1936.



to 15 feet high, was filled with sediment nearly to crest level.

These and numerous other examples support the conclusion expressed elsewhere in this report that the sediment in the New River is largely derived from slope and gully wash rather than from scouring and lateral cutting of the main channel.

Summary of Reservoir Sedimentation. - The principal data obtained from the four detailed reservoir surveys are summarized in Table 1.

Table 1. -- Summary of sedimentation in Fields, Washington Mills, Byllesby, and Buck Reservoirs.

	Name of Reservoir			
	Fields	Washington Mills	Byllesby	Buck
Age (Years)	5.67	33.5	23.66	23.66
Original capacity Acre-feet	183.81	2,954.24	8,892.16	1,225.33
Present capacity Acre-feet	109.22	511.47	3,538.35	941.51
Sediment Acre-feet	74.59	<u>1922</u> 2,363.96	<u>1936</u> 2,442.77	5,353.81
Percent Orig. cap'y.	40.58	80.02	82.69	60.21
Storage loss per year Acre-feet	13.16	<u>1902-22</u> 118.20	<u>1922-36</u> 5.84	226.28
Percent orig. cap'y.	7.16	4.00	0.20	2.54

A study of the character and distribution of sediment in the four reservoirs surveyed leads to the following general conclusions:

- (1) The sediment carried by the New River consists of dark gray silt and sand with only a minor quantity of gravel and organic material.
- (2) All 4 reservoirs are channel lakes, very little wider than the original river channel, with unusually steep bottom gradients. Consequently, currents have been an important factor in the life history of these reservoirs, as shown by the definite alignment of bottom sediment into bars parallel to the shores, and also by the large proportion of sand mixed with silt near the dam. Such currents tend to concentrate sediment in the lower and deeper parts of the reservoir. There is no sharp distinction between delta deposits and bottom-set beds.



- (3) The presence of such a channel-type reservoir even a short distance above a projected dam site is no insurance against storage capacity loss by silting of the new reservoir. For example, although Byllesby Dam is only 9 miles below Washington Mills Dam, it has silted up at the rate of 226.28 acre-feet per year, an annual decrease of 2.54 percent of its original capacity. Washington Mills Reservoir, however, had been accumulating silt for 10 years when Byllesby Dam was constructed, and is estimated to have lost at least 65 percent of its original capacity and likewise most of its effectiveness as a silt trap at that time. A better example is Buck Reservoir, only 3 miles below Byllesby and built in the same year. This reservoir has lost 23.16 percent of its original capacity in 24 years, despite the presence of a much larger reservoir a short distance upstream. Since no tributaries enter the New River in the intervening 3 miles, practically all the sediment in Buck Reservoir must have passed over Byllesby Dam. Approximately 35 percent of the sediment in Buck Reservoir is sand. Although most of this coarser sediment passed through Byllesby Reservoir in flood times when current action was strong, an unknown but obviously small fraction represents bedload deposits from the 3-mile stretch of river between the two reservoirs. But even if it be assumed that all of the sand in Buck Reservoir came from this latter source, a storage depletion of 15 percent would still have to be attributed to silt which had passed through Byllesby Reservoir.
- (4) Buck Dam, with an original height above stream bottom of about 20 feet, has stopped a fair amount of silt whereas Fields Manufacturing Company Dam, less than 10 feet high, has had practically no effect on the silt load of the stream. There is a critical height therefore, between 10 and 20 feet below which a dam in the New River will stop nothing but sand and coarser material.

In order to develop the significance of the rate of silt accumulation in relation to drainage area the data in the tabulation on page 18 were computed, the figures representing the totals of all four reservoirs. From these figures it appears that the average accumulation per year is 0.63 ton from each acre of drainage area. This figure, of course, represents only an indeterminate fraction of the net erosion of the watershed, since it is evident that considerable streamborne sediment passes the whole series of dams, and other volumes of sediment are being deposited outside the reservoirs as channel bars and islands. Average losses of soil from the lands of the watershed are, therefore, much greater than 0.63 tons per acre and, as alluvial readjustments progress, a gradual increase in potential rate of silting of any additional reservoir constructed in the valley is to be expected.

Further, inasmuch as the total remaining storage capacity of all 4 reservoirs is very small, it appears that within a few years the entire volume of erosional debris from the watershed will pass unchecked downstream into any new reservoirs at a rate exceeding 250 acre-feet per year.



Statistical summary of composite data relative to the 4 New River reservoirs of Virginia, included in this survey.

	Quantity	Unit
<u>1/ Age:</u> . . . . .	33.5	Years
<u>Watershed:</u>		
Total area . . . . .	1,320	Square miles
<u>Reservoir:</u>		
Original storage capacity . . . . .	13,255.54	Acre-feet
Present storage capacity . . . . .	5,100.55	do
Original storage per square mile of drainage area. :	10.04	do
Present storage per square mile of drainage area. :	3.86	do
<u>Sedimentation:</u>		
Total sediment . . . . .	8,154.99	Acre-feet
Accumulation per year average . . . . .	243.43	do
Accumulation per year per 100 square miles drainage:		
area . . . . .	18.44	do
Accumulation per year per acre of drainage area. . :	12.55	Cubic feet
Or, assuming average weight of 1 cubic foot of silt:		
is 100 pounds . . . . .	.63	Tons
<u>Depletion of storage:</u>		
Loss of original capacity per year . . . . .	1.84	Per cent
Loss of original capacity to date of survey . . . . :	61.52	do

1/ Date storage began in the oldest reservoir of the series studied, November 1902; date of this survey, May 1936.



## SEDIMENTATION IN RELATION TO NAVIGATION IMPROVEMENTS

Three sections of the New River which had been improved for navigation were investigated for the purpose of gathering information on sediment transportation by the New River and its possible effects on these improvements. Attention was especially directed to the old navigation channels, excavated through rock shoals by U. S. Engineers in 1878-89. Field examination of these channels was supplemented by interviews with old residents along the river, and with the U. S. Engineer's Office at Hinton, W. Va. The sections examined are as follows: (1) Lower or Greenbrier Division, extending from Hinton, W. Va., to the head of Wylie's Shoals, a distance of 26.5 miles; (2) Middle of New River Bridge Division, extending from the New River bridge at Radford, Va., to the head of Pine Run Ledges and Shoals, a distance of 27.8 miles; and (3) Upper or Lead Mines Division, extending from the lead mines at Austinville, Va., upstream for a distance of 8 miles. The extent of the improvements in these three sections is brought out in table 2.

Lower Division. - Navigation improvements were observed at the following locations: (1) opposite the mouth of the Greenbrier River, (2) opposite the Bluestone CCC Camp, about 2 miles above the mouth of the Greenbrier River, (3) about 1 mile below the mouth of the Bluestone River, (4 and 5) at points about  $1\frac{1}{2}$  and 3 miles, respectively, above the mouth of the Bluestone River, (6) at Bull Falls, (7) opposite the mouth of Indian Creek (8) about 1 mile above the upper end of Crumps Bottom, (9) about 1 mile below Wylie Island, and (10) at Wylie Falls. The improvement in each case consisted of a channel blasted through bed rock shoals or riffles, except improvement No. 2, which is a rock-filled crib constructed to deflect the current to aid navigation.

Very little positive information on the conditions of these channels was available. The United States Engineers have recently taken soundings every half mile in the area of backwater of the proposed Bluestone Dam, but according to their statement these profiles were generally taken in quiet reaches for greater ease in handling boats and sounding apparatus, and hence missed the channels through the shoals. Other persons interviewed were Mr. Fred Sims, who has had many years experience running boats between Hinton and Bull Falls and Mr. Haines, owner of Haines Ferry, just above the mouth of the Bluestone River, who has spent a lifetime on the river.

None of the people interviewed has seen any evidence of deposition in the channels, and they are all convinced that the current is strong enough to keep them scoured out. Field observations are entirely in agreement with this conclusion, since every channel examined was in rapid water flowing over ledges of bedrock. The average gradient of the Lower Division is about 4.5 feet per mile. The channels are best recognized by the spoil banks thrown up alongside, composed of boulders and rock fragments blasted from the ledges, which have remained intact for fully 50 years. These now appear as chains of small willow-covered islands.

Detailed Studies. - In order to obtain definite information on sediment and discharge conditions in these improved sections, navigation channels at the following locations were chosen for special studies and measurements:



Table 2--Statistics on navigation channels in the New River<sup>1/</sup>

	Lower Division	Middle Division	Upper Division
Average width of channel .....	Feet	30	20
Depth below lowest water .....	do	2	2
Average cross-section area .....	Sq.Yds.	6.67	4.44
Volume of material excavated .....	Cu.Yds.	6,420	2,148
Computed length of channel with average cross section area .....	Yards	963	484
	Miles	0.55	0.27
Total length of improved channel .....	Miles	12.0	13.3
Percent of total improved channel length which was excavated .....	Percent	4.3	5.0
Total improved channel length in all 3 divisions .....	Miles	62.3	
Total computed channel length in all 3 divisions .....	do	3.08	
Percent of total channel length which was excavated (in all 3 divisions) .	Percent	4.94	
Total river length in all 3 divisions .	Miles	191.5	
Percent of total river length which was excavated .....	Percent	1.6	

1/ Based on unpublished data in the files of the U. S. Engineers.

NOTE: In the above figures no allowance was made for an original depth of water before excavation, the depth of excavation being taken as 2 feet in each case. Hence, the actual length of cut channel represented by the total volume of material excavated is greater than the figures given, which are intended only as an approximation. "The low water depth (of the undisturbed channel) varies from a few inches to more than 6 feet." (U. S. Engineers report on Kanawha River, House Doc. No. 91, 1935).



- (1) A section 1.1 miles above Haines Ferry, or 8 miles above Hinton, W. Va.
- (2) Opposite the mouth of Indian Creek, or 18 miles above Hinton, W. Va.
- (3) One and three-fourths miles above the mouth of Indian Creek or 20 miles above Hinton, W. Va.

At each of these sites the slope of the channel was obtained by levels, one or more typical cross sections were located and measured by stadia, and current velocities were measured by means of surface floats. In each case, the material of the channel bottom was carefully noted.

Navigation channel 1.1 miles above Haines Ferry. -- This channel lies near the left bank of the river and extends parallel to the shore across a series of low shoals for a distance of approximately 1,600 feet. Cross sections were obtained at transverse ranges established near the upper and lower ends and at 3 intermediate points on this channel. Although velocity and discharge measurements were obtained for the entire channel and for the various segments between ranges the results on some segments were so divergent, owing to effects of cross currents from side channels, that one of the center segments, completely bordered by exposed spoil banks, was selected as giving the most accurate figures on the velocity and discharge of the channel. Mean velocities were determined by applying a correction factor of 0.85 to the surface velocities as obtained by floats. 4/

The data on the selected segment of the channel are summarized in the following tabulation; the figures on width, depth, and area are the mean values of the cross-sections at each end of the segment:

Width-----	29.5 feet
Average depth-----	2.28 feet
Area of cross section-----	67.37 square feet
Observed surface velocity---	3.72 feet per second
Mean velocity (obs. vel. x 0.85)-----	3.16 feet per second
Character of bottom-----	Smooth bedrock with a few large blocks
Discharge through channel---	212.89 C.F.S.
Length of segment-----	185 feet
Average slope of entire channel-----	2.52 feet per 1000 feet
Stage of river at Packs Ferry (2.81 miles downstream)--	4.0
Discharge of New River on same day-----	4,390 cubic feet per second

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4/ Breed & Hosmer, The Principles & Practice of Surveying; Vol. II, Higher Surveying, John Wiley & Sons, 1934.

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The mean velocities for the four segments were as follows:

Upper segment-----	4.0 feet per second
Second segment-----	3.16 feet per second
Third segment-----	3.64 feet per second
Lower segment-----	2.86 feet per second

The following figures on the minimum bottom velocities required to produce motion in various-sized material are taken from a table by Parker, in Control of Water, Van Nostrand, 1915:

<u>Material</u>	<u>Velocity, ft./sec.</u>	<u>Remarks</u>
Gravel or coarse sand-----	1.0	Affected by shape of grains.
Pebbles 1 inch in diameter-----	2.0	
Pebbles, egg size-----	3.0-3.3	Shape of masses ceases to have marked effect.
Stones 3 inches in diameter-----	5.0	These figures are of doubtful value due to inaccuracy in determining bottom velocity.
Boulders 6" to 8" in diameter-----	6.6	
Boulders 1' to 18" in diameter-----	10.0	

The above figures indicate that, with the velocities found in this channel at moderately low stage, all material except large boulders would be swept away. In fact, the only loose material in the channel was a few large blocks of bedrock ranging from several inches to a few feet in diameter. These blocks unquestionably were either left in the channel at the time of excavation or have slid down the steep sides of the adjacent spoil banks which are composed of similar blocks.

Navigation channel opposite the mouth of Indian Creek.-- This channel extends diagonally across a series of shoals, with a total length of approximately 2,000 feet and a total fall of 6.26 feet (fig. 27).

The measurements taken at this site were similar to those at the preceding one, except that velocities were determined only in a single reach. The significant data are as follows:

Width-----	45 feet
Average depth-----	2.35 feet
Cross section area-----	105.73 square feet
Length of segment-----	522 feet
Observed surface velocity-----	6.21 ft. per second
Mean velocity (Obs. vel. x 0.85)-----	5.28 ft. per second
Character of bottom-----	Smooth bedrock
Discharge through channel-----	558.25 cu. ft. per second
Slope of segment-----	2.81 ft. per 1000 feet
Stage of New River at site-----	2.1 feet
Discharge of New River on same day-----	3,920 cu. ft. per second

The velocity in this channel, according to Parker's table, is sufficient to move stones 3 inches in diameter. It was found during the survey that the bottom was clean bedrock, free of all loose material.



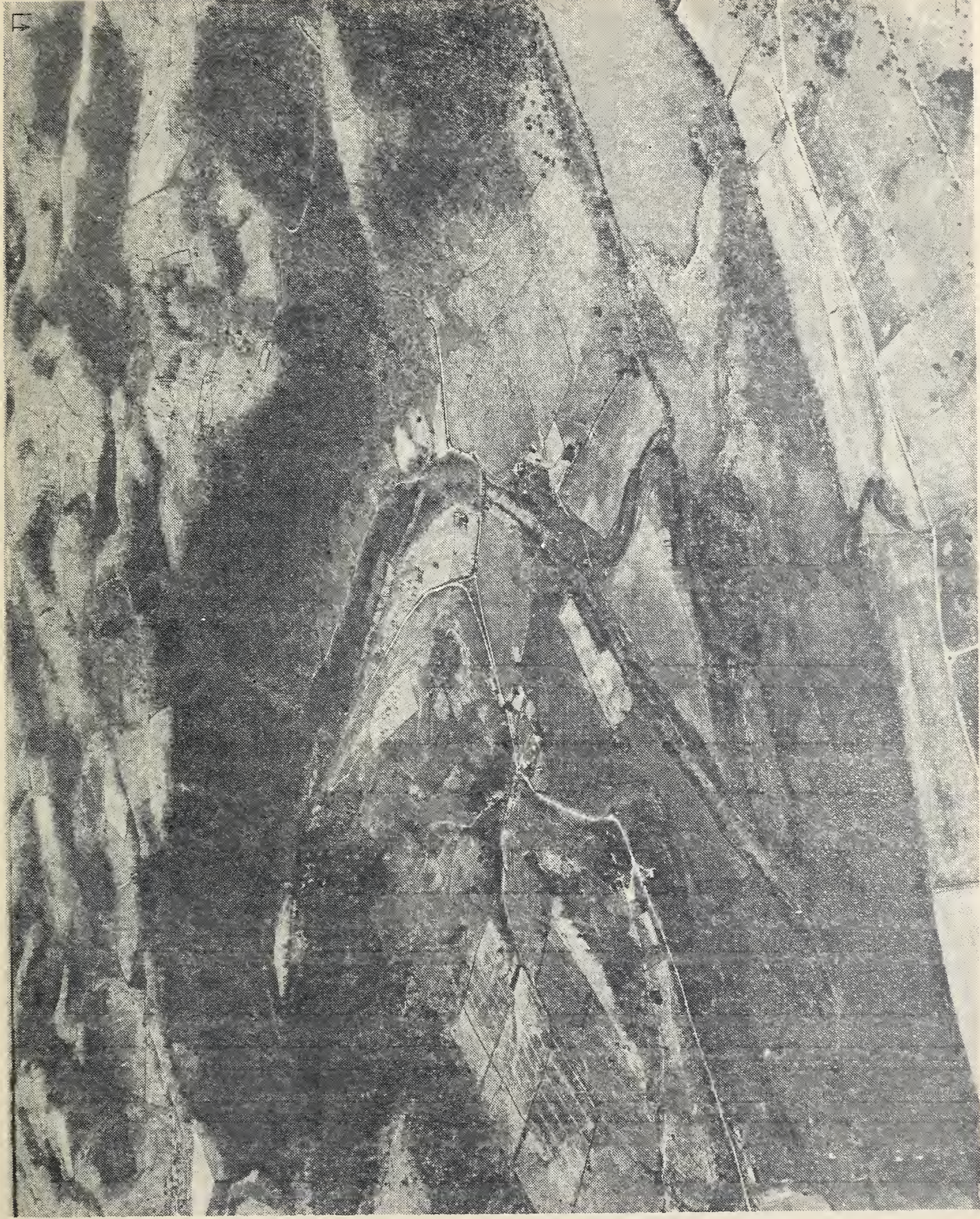


Figure 27. Navigation channel at the mouth of Indian Creek, about 18 miles above Hinton, W. Va. The channel extends diagonally across the riffles in the right foreground. (Courtesy of Aerial Surveys of Pittsburgh, Inc.)



Navigation channel 1-3/4 miles above the mouth of Indian Creek.--  
This channel lies near the right bank and cuts across an abrupt fall, with a total drop of 3.35 feet in a distance of 600 feet (fig. 28). One cross section was measured and velocities determined in three segments of the channel.

The following data were obtained:

Width-----	41 feet
Average depth-----	3.32 feet
Cross section area-----	136.15 square feet
Observed surface velocity	
Upper reach-----	3.86 feet per second
Center reach-----	9.36 feet per second
Lower reach-----	4.08 feet per second
Mean velocity (Obs. vel.x 0.85)	
Upper reach-----	3.28 feet per second
Center reach-----	7.96 feet per second
Lower reach-----	3.47 feet per second
Character of bottom-----	Smooth bedrock
Discharge through center reach-----	1083.75 cu. ft. per second
Slope of center reach-----	9.65 ft. per 1000 feet
Slope of entire channel-----	5.36 ft. per 1000 feet
Stage of New River at Indian Creek----	1.9 feet
Discharge of New River on same day----	3920 cu. ft. per second

The upper reach extends above the main shoals and the lower section extends below the foot, the center section alone being entirely within the fall. The mean velocities given above indicate, according to Parker's figures, that large stones might remain in the upper and lower reaches, but that boulders up to one foot in diameter would be moved in the center reach.

The survey showed that the center reach was floored with smooth bedrock, devoid of any loose material.

Middle Division. - The only navigation channel observed in the Middle Division was at the mouth of Peaks Creek, about 5 miles due east of Pulaski, Va. It was recognized only by an occasional slight break in the riffles, and a chain of small willow-covered islands marking the spoil banks. The average gradient of the middle section is about 4 feet per mile. No indication of channel filling was observed. This channel, consisting merely of notches in successive shoals, was not suitable for velocity and discharge measurements.

Upper Division. - The average gradient of the New River in the Upper Division is about 8 feet per mile. No trace of navigation channels was observed, either from aerial photographs or from the ground. The current in this section of the New River is obviously too swift to allow appreciable deposition in any part of its channel.





Figure 28. Navigation channel on the New River, about 20 miles above Hinton, W. Va.  
The spoil bank to the left of the channel is clearly shown above water level.  
(Courtesy of Aerial Surveys of Pittsburgh, Inc.)



## SEDIMENTATION OUTSIDE OF NAVIGATION CHANNELS

There is evidence that sediment is accumulating locally along the course of the New River although not in the relatively steep artificially excavated sections of the navigation channel excavated in bedrock at the sites of natural rapids. Mr. Haines, who owns land extending for 2 miles along the river adjacent to Haines Ferry, stated that farms along the river bottom were "gaining land" through the growth of bars and islands by deposition of sand and silt. Corroboration of this statement was found about  $1\frac{1}{2}$  miles below Bull Falls in the form of sand and silt bars and islands, some of which were of very recent origin. One bar about 50 feet wide and several hundred feet long was composed of uncompacted silt and sand. Several small islands occur in the river at this point, and although islands are shown here on the topographic sheet of the Big Bend Quadrangle, mapped in 1927, fresh additions of sand were noted on all of them, and the number of islands appears to have increased.

Comparison of maps made by U. S. Engineers in 1924 and in 1935 shows that an island just above the mouth of the Greenbrier River has lengthened downstream approximately 600 feet in this 11-year period. Inspection of the more recent topographic maps shows that bars and islands are not uncommon along the New River from the North Carolina-Virginia boundary to Hinton, W. Va.

## CONCLUSIONS

The investigations on New River show that sediment is accumulating in places in the natural river channel but not in the artificial channels that have been excavated in bedrock at the sites of natural rapids of the river. The accumulations of sediment in the reaches where slopes are relatively low between the sites of natural rapids are in the form of bars along the river banks and both bars and islands in the river channel. These accumulations tend to restrict the river channel, reduce the channel discharge capacity, raise flood levels and adversely affect navigation.





